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PROGRESS IN THE PREVENTION AND CONTROL OF AIR POLLUTION. SECOND REPORT OF THE SECRETARY OF HEALTH, EDUCATION, AND WELFARE TO THE CONGRESS OF THE UNITED STATES IN COMPLIANCE WITH PUBLIC LAW 90-148

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, WASHINGTON, D. C.

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The second of a series of reports describing U.S. progress in preventing and controlling air pollution, covering the period of May, 1968, to January, 1969. It updates the first report of May, 1968, reporting new activities that have been initiated since that time and providing an overview of the Federal program to restore and maintain the quality of U. S. air resources.

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Preface

This is the second of a series of reports which will describe the progress being made in this country to prevent and control air pollution. The report covers a period from May 1968 to January 1969. It is respectively submitted in accordance with Section 306 of Public Law 90-148, the Air Quality Act of 1967, which states as follows:

> Section 306. Not later than six months after the effective date of this section and not later than January 10 of each calendar year beginning after such date, the Secretary shall report to the Congress on measures taken toward implementing the purpose and intent of this Act including but not limited to (1) the progress and problems associated with control of automotive exhaust emissions and the research efforts related thereto; (2) the development of air quality criteria and recommended emission control requirements; (3) the status of enforcement actions taken pursuant to this Act; (4) the status of State ambient air standards setting, including such plans for implementation and enforcement as have been developed; (5) the extent of development and expansion of air pollution monitoring systems; (6) progress and problems related to development of new and improved control techniques; (7) the development of quantitative and qualitative instrumentation to monitor emissions and air quality; (8) standards set or under consideration pursuant to title II of this Act; (9) the status of State, interstate, and local pollution control programs established pursuant to and assisted by this Act; and (10) the reports and recommendations made by the President's Air Quality Advisory Board.

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I. INTRODUCTION

It is the intent of this report to update such information as was reported in the first progress report to the Congress on the prevention and control of air pollution in May 1968. The report introduces new activities which have been initiated during the reporting period, as well as provides an overview of the Federal program aimed at restoring and maintaining the quality of the Nation's air resources.

The Federal responsibility for pursuing the problems of preventing and controlling air pollution is that of the Department of Health, Education, and Welfare, through provisions of the Air Quality Act of 1967. Under the Act, the Department seeks a regional approach to air pollution control. To carry out the operating requirements of the Act, the Department has established the National Air Pollution Control Administration under the Consumer Protection and Environmental Health Service. The Administration, formerly the National Center for Air Pollution Control, conducts a comprehensive program of research and training, financial and technical assistance to State and local agencies, and abatement and control activities to help protect the Nation from the harmful effects of air pollution. The Administration's specific aims are to optimally increase knowledge of the nature, sources, effects, and control of air pollution and to achieve maximum application of that knowledge. Organizational elements of the Administration reflect the support of these aims.

II. CONTROL TECHNOLOGY RESEARCH AND DEVELOPMENT

A. Stationary Sources

The programs to develop effective methods for control of stationary sources were expanded from $9.0 million in fiscal year 1968 to anticipated expenditures of over $14.0 million during fiscal year 1969. Programs to develop the large-scale equipment studies necessary to firmly evaluate first-generation processes for control of pollution from combustion were given continued high priority, and programs to develop new processes were expanded to give increased attention to pollutants other than sulfur oxides originating from combustion of fuels. The most significant change in emphasis during the past year was an increase in the resources being devoted to a series of systems studies instituted to provide better definition of the nature of the research and development needed to cope with the diversity and complexity associated with any major segment of the air pollution problem presented by stationary sources in their totality.

These studies include: (1) Industry-wide surveys of basic industries such as primary smelters, pulp and paper, iron and steel, etc. In all these surveys, combustion processes will be given special attention. (2) Device-oriented studies to assess problems that must be solved to permit wider application of electrostatic precipitators, fabric filters, scrubbers, and afterburners. (3) Pollutant-oriented studies to provide better definition of the relative contributions of and control problems associated with important pollutants such as nitrogen oxides, particulates, and odors on a nationwide basis.

All of the systems studies involved have certain common characteristics, whether they are pollutant-oriented, device-oriented, or industry-oriented. In all, the intent will be to accumulate the best possible data, even where doing so will be a difficult job. Most studies are expected to provide a broad base of information that can be used by any groups interested in analysis of any segment of the problems. The availability of such information is expected to eliminate the need for considerable duplication of effort by those with potential to contribute to the solution of existing problems.

Efforts to continue expansion of the base of technical competence supporting the program have resulted in an increase in the number of participating groups so that NAPCA is either conducting such projects or is directly utilizing competence available in over 70 groups in industry, universities and the National Academy of Engineering, and other government agencies. Particular emphasis has been given to increasing the degree of involvement with groups outside of the United States. Foreign activities have resulted in enlargement of our international activities in England, Germany, and Japan to include cooperation and/or probably joint research with groups in Yugoslavia, Czechoslovakia, and Canada. Through the mechanisms available for conducting research with funds available under P.L. 480 for expenditure overseas, projects in Poland and India are expected to be developed in the coming year.

1. Control of Sulfur Oxides Pollution. The previously formulated program to develop control methods for the various sources of sulfur oxides pollution has progressed along anticipated lines set down in past years; however, overall funding was lower than anticipated so that some processes that are candidates for scale up are being given more detailed study on small systems. Although this may slow down the rate at which processes become available, it is likely to increase the probability that they will be economically acceptable.

a. Removal of Sulfur from Coal. Because many small combustion units are not amenable to control by processes now being developed, burning of low sulfur fuels is probably the most practical immediate answer to the problem created by these sources. The known reserves of low sulfur coals are limited, however; and therefore, the National Air Pollution Control Administration has a program underway to develop an inventory of cleanable coals and economical techniques for removing sulfur from coal. In addition to the inventory, the coal survey studies are producing comprehensive information on the amounts of sulfur that potentially can be removed from high-sulfur steam coals.

(1) Coal-Washing Studies. As part of its evaluation of commercial methods for separating pyritic sulfur from coal, NAPCA is developing information on the operational characteristics of these methods when applied to various representative coals through a private contractor. In addition, NAPCA is supporting two equipment studies by the Bureau of Mines. The Bureau is evaluating modifications that could improve the separation capabilities of available equipment.

Two other private contractors have completed their evaluation of fluid bed roasting of pyrite-coal mixtures and subsequent conversion of the sulfur dioxide released into sulfuric acid. This study has defined the economics and technical limitations of increasing amounts of coal with the pyrite feed material. As a result of an investigation of other related technology, another contractor has developed approximate costs for a process that would burn pyrite-coal rejects in a specialized boiler for generating electrical power and recovering sulfuric acid from flue gases. This process would produce a low-sulfur coal and a reject material that could be burned in a power-generating plant without emitting polluted flue gases. Further study of this method will define in detail the technical and economic factors involved.

Competitive designs of prototype coal-cleaning plants and associated cost analyses are being done through a contractual arrangement. Following completion of these studies in the latter part of fiscal year 1969, construction and operation of a prototype coal-cleaning plant is planned, as well as design selection and construction of one or more reject utilization processes.

b. Removal of Sulfur from Fuel Oil. NAPCA is maintaining its awareness of progress in residual oil desulfurization. Several direct and indirect desulfurization units have been installed at refineries, and more are planned for the future. The success of these units is being followed with interest to determine whether support of research and development could help increase the effectiveness of the units or reduce desulfurization costs. One area of technology that appears to require further research is development of a

hydrodesulfurization catalyst that would not be deactivated by heavy metal contaminants in residual fuel oil.

c. Removal of Sulfur Oxides from Fuel Gas. Even though developments in fuel desulfurization, fuel conversion, and modified power cycles may provide a more practical long-term solution to the sulfur oxides pollution problem, the best available estimates of process economics and the more advanced stage of development of various processes for flue gas desulfurization make it likely that short-term processes for removal of sulfur from effluent gases will make the greatest contribution to control of sulfur pollution.

During the past year, the Monsanto Chemical Company announced the successful operation and availability of its catalytic oxidation process, which converts sulfur oxides to 70 percent sulfuric acid. Combustion Engineering, Inc., sold two lime scrubbing processes, which are now operable. Several proprietary processes have been declared successful by their developers on the basis of limited small-scale tests. These include the Wellman-Lord process, now being scaled up to a 25-megawatt prototype unit on a Baltimore Gas and Electric Company Plant, and Stone and Webster's process, which has been operated successfully on a small-scale pilot plant.

Foreign processes have also been evaluated on a prototype scale. These include the Mitsubishi Heavy Industry process, which employs manganese oxide as a sorbent, and the Hitachi Manufacturing Company's wet char process which produces dilute sulfuric acid as a byproduct. Conditions in the foreign power industry and byproduct markets make these processes uniquely applicable to control the

problems for which they were developed. As a result, they have limited or little potential for application to the U.S. problem.

New process development sponsored by NAPCA resulted in paper and bench-scale research of promising new processes. Among the leading candidates from this work are several regenerable wet scrubbing processes. Negotiations are underway to move these studies to the pilot-land stage within the next few months.

The NAPCA sulfur oxides control research and development program continues to give careful attention to developments being made by the U.S. industrial community and in foreign countries to avoid duplication of effort and to concentrate effort on processes that appear to have maximum potential for providing immediate relief from the sulfur oxides pollution problem. Considerable attention continues to be given to the limestone-based processes, with increased emphasis on wet limestone scrubbing research and development to identify and solve engineering and process problems that currently limit the utility of this control method. Sorbent problems in the alkalized alumina process have tended to restrict progress on this process.

(1) Limestone-Injection Process. Recognition by government and industry of the immediate need for air pollution control systems, specifically for control of sulfur oxides, has led to rapid advances in the development of two variations of limestone-based processes: dry limestone injection and limestone injection combined with wet scrubbing. It is believed that both the acceptance

and potential of the dry injection process will be established upon completion of the full-scale trial of the process by TVA under NAPCA sponsorship. Installation of equipment for the multi-million dollar trial is underway at TVA's Shawnee Power Station, near Paducah, Kentucky.

Preparatory to the full-scale trial, Babcock and Wilcox, Inc., has constructed a 1:6.5-scale model of TVA's Shawnee No. 10 unit, the unit in which the full-scale dry limestone injection trial will be conducted. Cold tests of the additive injection system are underway and dispersion of the dust in the simulated furnace and convection passes of the boiler are being studied. NAPCA, in cooperation with the Florida Power Company, this year conducted short-term injection tests to study the effect of high-temperature injection on the sorption properties of calcined limestone and dolomite. In its program of fundamental and applied research, under contract and in-house, NAPCA is developing data to assist in optimizing the limestone process and achieving maximum performance in the prototype injection trials by TVA. In addition to the five fundamental and applied research contracts negotiated in 1967, which were described in the first report, several additional contracts were initiated during 1968. A full-scale test program is being sponsored by NAPCA at a facility of the Peabody Coal Company in Columbia, Tennessee. The company is using a special chain grate stoker to study the efficiency of various alkaline earth additives in removing sulfur dioxide from flue gas. The results of this test program may have

considerable application for control of sulfur oxides pollution from industrial combustion units.

The City of Chicago recently completed trials of limestone injection processes for limestone and a waste material called "red mud," a waste product from the processing of aluminum ores. NAPCA is evaluating this material in-house in bench-scale experiments. The General Motors Company, Chevrolet Division, St. Louis plant is progressing with a full-scale industrial test of the dry injection process. NAPCA is cooperating with both the City of Chicago and General Motors by providing information available on boiler injection processes from its bench-scale tests. The contract with Esso Research and Engineering Company has been extended to include investigations of the technical and economic aspects of regenerating reacted limestone and sulfur oxides products to permit recycling of the sorbent material.

TVA completed a conceptual design and economic evaluation of the dry injection process and will shortly complete a similar study of the wet scrubbing process. Other investigators studied the mineralogical, physical, and chemical properties of a wide range of limestones and dolomites and evaluated their reactivity with sulfur oxides in various experimental reactors--in some cases, under conditions closely simulating those in power plant boilers.

TVA's economic study of the dry process estimates a total operating cost of approximately $1.05 per ton of coal in a 200-megawatt coal-fired boiler. The above cost is based on a coal

containing 3.5 percent sulfur, a limestone cost of $2.05 per ton delivered, and addition of two times the theoretical amount of limestone required to absorb all the sulfur in the coal. Economic utilization of the limestone-modified fly ash product could lead to lower costs. Work at the Coal Research Bureau at West Virginia University has shown that mineral wools having acceptable properties can be made from this product. The Coal Research Bureau is also investigating the possibility of recovering the unreacted quicklime portion for possible recycling in the process.

Work to date with the dry injection process indicates the need for a better understanding of the chemistry of the process and factors important to achieving maximum performance. Further research and development is needed specifically (1) to define the fundamental kinetics of the sulfur oxide reaction with calcined limestone, (2) to explain the effects of overcalcination on the reactivity of limestone, (3) to develop criteria for selecting the most reactive limestones or dolomites for use in the process, and (4) to develop ways of utilizing limestone-modified fly ash and thus make the process more attractive economically and at the same time reduce the waste disposal problem.

Continuing emphasis is being placed on development of the wet limestone process not only because of the potential of the aqueous lime scrubbing process for the control of sulfur oxides but also because of the need to solve engineering and process problems that may limit its application. In the lime scrubbing process, dry limestone injection into a power plant boiler is followed by wet

scrubbing of the flue gas for removal of both fly ash and calcined lime. While in the scrubber the milk-of-lime reacts with the sulfur dioxide in the flue gas to form a disposable solid waste product. This process has potential for application to large and small, new and existing power plants.

Unsolved problems that may limit effectiveness of the wet limestone process include corrosion and erosion of process equipment, localized air pollution resulting from inadequate plume buoyancy, potential for water pollution resulting from disposal of solid and liquid waste products, and lack of reliable data for scale-up of the scrubbers to sizes that will be necessary for power plant usage. To define these potential problems and solve them, NAPCA has negotiated a contract for a preliminary design of a large-scale prototype test facility. The facility will consist of three parallel prototype scrubber units, each capable of processing flue gas approximately equivalent to that from a 25-megawatt power boiler. The units will be designed to permit a comparison of at least three process variations, including scrubber types. Emphasis will be placed on the development of process kinetics and economics and generation of data needed for optimum process scale-up. These test facilities are expected to be constructed and in operation by the end of calendar year 1969.

(2) Alkalized Alumina Process. Planning and activities directed toward the two large-scale studies of alkalized alumina in the United States and England are being continued. NAPCA and the

Electric Research Council have obtained many of the clearances required for joint support of the British prototype-scale studies. Similar progress on the British side by the Central Electricity Generating Board is not evident; CEGB has been asked to clarify its position with respect to continued interest and the financial capability to support the work.

Projects aimed at developing the U.S. version of the alkalized alumina process are being continued at a high level of priority. Both British and U.S. workers have recently encountered difficulties with sorbent deterioration, however, and believe that this problem must be overcome before a prototype plant is designed and built. Intensive efforts are underway to provide and evaluate a satisfactory alkalized alumina sorbent, identify the most economic process consistent with the characteristics of the best available sorbent, and assess the technical and economic feasibility of the process as a basis for making a decision on scale-up of the prototype. While these critical factors are being evaluated, NAPCA is continuing the work and negotiations required for scale-up of the process to prototype if sorbent problems are overcome and process evaluation is favorable.

Most of the work aimed at producing a stable sorbent is being done by W.R. Grace and Company; this activity represents a shift of emphasis from process scale-up for production of larger quantities of sorbent. NAPCA is also funding an effort by the Bureau of Mines to produce a large handmade batch of the original sorbent produced by the Bureau, apparently the only sorbent that has withstood simulated process conditions.

M.W. Kellogg and Company has a program well under way to evaluate existing information on the alkalized alumina process, define technology deficiencies, and perform a comprehensive design study and economic evaluation directed toward large-pilot-plant demonstration studies. Kellogg has developed preliminary flow sheets for three versions of the process: fixed bed, dispersed bed, and fluid bed. The company has indicated that data on sorption kinetics are now well enough developed, but has reemphasized the need for additional data on regeneration. Two projects at the Bureau of Mines are being reshaped to provide specific data required. Bench-scale studies on fluid-bed sorption and regeneration have been started at the Bureau of Mines. Kinetics, modeling, alternative sorbent, and panel contactor work are largely completed. A copper oxide alumina sorbent has shown some promise, and an analogous proprietary material has been received from a catalyst manufacturer for evaluation.

d. New Process Development. New process development activities are receiving broad coverage in nine areas of technology: (1) aqueous scrubbing, (2) solid metal oxides, (3) inorganic liquids, (4) organic liquids, (5) inorganic solids excluding metal oxides, (6) organic solids, (7) catalytic oxidation to sulfuric acid, (8) reduction to sulfur, and (9) physical methods of separation. These nine areas are being surveyed to obtain sufficient information for assessment of the potential of all new processes.

Battelle Northwest is continuing its technology review of organic liquids, and in the field of molten inorganic materials the team of MSA Research and Singmaster-Breyer is continuing a state of the art survey. Since mid-1967, Atomics International Division of North American Rockwell has been investigating an approach known as the molten carbonate process. The company has completed the design of a small pilot plant; and if the present rate of development continues, a prototype system for a 50-megawatt power plant could be in operation by 1972. The process uses molten salts to remove sulfur dioxide from flue gases and produces elemental sulfur as a byproduct. A major problem in this development is corrosion; however, data generated over the past several months indicate that this problem may have been solved.

Monsanto Research Corporation is investigating new, improved catalysts for the oxidation of sulfur dioxide to concentrated sulfuric acid. Tyco Laboratories is adapting chamber-process chemistry to the development of a gas-phase catalytic process that, if successful, would control sulfur oxides and nitrogen oxides simultaneously. Tyco has demonstrated all reactions in the laboratory and is constructing a bench-scale plant for continuous operation. Callery Chemical Company is investigating a process for concentrating sulfur trioxide that could be used in conjunction with a catalytic oxidation process.

Allied Chemical Corporation is surveying the state of the art of reduction of sulfur dioxide to sulfur. Princeton Chemical Research is investigating a specific direct reduction process in which part of the sulfur produced is catalytically converted into

the reducing agent. Princeton is also designing a small pilot plant including a pulverized-coal-fed furnace that should be in operation this year.

Tracor, Inc., is studying dry metal oxides and providing thermodynamic data to other contractors. Aerojet General is investigating aqueous scrubbing processes.

TRW, Inc., is conducting the state of the art review of solid organic materials for sulfur oxides control, and FMC Corporation is well along in the survey of inorganic materials other than metal oxides, including char. The survey incorporates reviews of the several char processes under development in Europe (mainly Germany) and Japan. Westinghouse Electric Corporation is exploring the entire field of physical methods of separation for removing sulfur dioxide from flue gases. General Electric Company is trying to develop a process based on the use of selectively permeable membranes for separating or concentrating sulfur dioxide.

Most of the nine area surveys should near completion by the end of fiscal year 1969. At that time, in addition to the specific processes now being developed, the surveys will have resulted in the selection of other promising new processes for development. The contractors will have provided theoretical analyses, preliminary engineering designs, and economic evaluations for specific applications of these new processes. These results will coincide with progress in problem definition studies of specific industries and equipment.

As work on new processes has developed, two processes have shown potential for control of nitrogen oxides as well as sulfur oxides. The following section gives some specific details on these processes with discussion of additional support and consideration being given overall programs for control of nitrogen oxides.

2. Control of Nitrogen Oxides Pollution. The comprehensive systems study to define nitrogen oxides pollution problems and to develop a research and development program for control of the problem was started near the end of fiscal 1968. Esso Research and Engineering has gathered considerable information on the nature and magnitude of the control problem and on technology that has potential applicability to control of nitrogen oxides emissions. Identification of the type, number, magnitude, and location of sources will be followed by detailed recommendations for formulation of a research and development program.

Fundamental studies at the Bureau of Mines on the kinetics of nitrogen oxides formation in flames have been completed, and the final report is in preparation. NAPCA research on fuel additives and residential heating equipment is being continued. A commercially available combustion-improving device for residential oil-furnaces has shown promise for reducing emissions of nitrogen oxides and other pollutants.

Investigation of the potential of fluid bed combustion of coal as a means for controlling nitrogen oxides and sulfur oxides is being continued in pilot studies by Pope, Evans, and Robbins as part of a NAPCA cooperative study with the Office of Coal Research. At

Argonne National Laboratory, NAPCA launched a broad-based theoretical and bench-scale evaluation of additive materials and of combustor design and operating variables for control of nitrogen oxides and sulfur oxides in fluid bed combustion. A week-long symposium on fluid bed combustion sponsored by NAPCA included participation by representatives from four foreign countries as well as those from the United States working in the field.

NAPCA is evaluating new and improved sulfur oxides control processes for their potential in controlling nitrogen oxides. Development of the molten carbonate process for sulfur oxides control at Atomics International has been extended to include an evaluation of the process as a means for control of nitrogen oxides. An extension of the metal oxides thermodynamics work on sulfur oxides reactions to include nitrogen oxides reactions is under consideration. Further development of a macroscopic-scale model of nitrogen oxides formation during combustion is also being considered to complement the systems study being done by Esso Research and Engineering.

3. Control of Particulate Pollution. A contract research program directed toward the particulate pollution problem was initiated in the second quarter of fiscal year 1969. Emphasis is being given to defining the total national problem, identifying major sources of particulate pollution, determining the present degree of control, defining the body of available technology regarding important properties and characteristics of particulates, and formulating research and development programs necessary to generate information required for adequate control of particulates.

In addition to the survey of the national particulate pollution problem, NAPCA is continuing its in-house studies of equipment for control of particulates and other pollutants. NAPCA is studying five basic types of scrubbers to relate scrubber efficiency to economics of operation, to improve the effectiveness of scrubbers for control of incinerator emissions, and to develop new and improved scrubbing techniques such as condensation of water vapor on very small particles to facilitate removal. NAPCA is also continuing its in-house studies of fabric filtration, which is probably the most advanced technique for removal of very small particles. These in-house studies by NAPCA serve two purposes: (1) development of technology for solution of specific problems and (2) development of background and experience needed to manage the contract research program.

The NAPCA in-house studies, contract studies of devices and the contract survey and definition of the national particulate pollution problem complement new programs instituted to improve overall capabilities of the important types of equipment now used in air pollution control. (Device improvement studies are discussed in a later section.)

4. Control of Pollution from Specific Industries. NAPCA is expanding its series of studies of basic industries to develop a comprehensive body of information that will provide guidelines for all Federally sponsored research and development for control of air pollution from these sources. These studies will generate engineering

data and technical and economic feasibility analyses of alternative modes of control and will define research needs of the industry related to development of new and improved control techniques.

Work was started in 1967 with initiation of a study of the primary copper, lead, and zinc smelting industry. The series was expanded in 1968 to include systems studies for control of air pollution from the wood pulping, integrated steel and graphic arts industries. Although primary emphasis in the smelting study was given to sulfur oxides, later studies in the series are being broadened to include other significant pollutants such as odor-causing compounds, particulate fluorides, and solvents.

A diversity of private competence is being brought to bear on the examination of industry problems. For example, the team of E.R. Sirrine and Environmental Engineering is doing the wood pulping problem analysis. Battelle Memorial Institute and Swindell-Dressler are studying the integrated steel industry. Evaluation of the graphic arts industry problem is being done by the Graphic Arts Technical Foundation under a cost-sharing arrangement.

To the extent that it is practical, studies are being designed to meet the coordinated information needs of several NAPCA programs. This is being done to avoid unnecessary duplication of effort within NAPCA and to minimize requests to industry for responses to inquiries.

Where necessary, the active support and cooperation of operating management in the affected industry is being sought. Meetings are being called to explain the nature and purposes of the studies. A more formalized mechanism for industry involvement has been instituted with the creation of Industry Liaison Committees. These committees, usually composed of 10 to 12 industry representatives, are set up to follow progress of the studies and to offer an industry viewpoint on developments. Lines of communication are kept open to associations that represent small business enterprises to encourage cooperative support of studies designed to develop background data on specific control problems.

Future efforts by NAPCA will include a broad area study of air pollution controls for stationary fossil fuel combustion equipment. This project will be designed to investigate the problems of the great number of combustion units in residential, commercial, and industrial installations, exclusive of the large utilities. Together these installations burn more than 30 percent of the fossil fuels consumed. A broad attack on these sources is necessary because emissions from them often occur at low levels in or near populated areas.

5. Control of Pollution from Waste Disposal. Recent studies have shown that solid wastes from residential, commercial, and industrial sources exceed 200 million tons per year and is increasing at a compounded annual rate of 3 percent. Agricultural, forestry, and animal wastes greatly exceed this amount. The municipal disposal problem has already become critical because uncontrolled dumping and burning are unacceptable. With the trend toward more concentrated commercial operations and greater restrictions on levels of land and

water pollution, similar problems are becoming evident in the disposal of agricultural, forestry, and animal wastes. The thermal destruction of wastes of all types will be increasingly employed despite the resulting air pollution. Consequently, efficient incineration processes and associated air pollution control methods must be developed suitable to the types, quantities, and locations of the wastes generated.

Broad systems studies are being designed to define the overall air pollution problem associated with refuse disposal. The first such study is now being performed by Arthur D. Little, Inc. This contractor is assessing present and projected emissions resulting from incineration of municipal refuse and analyzing all technically and economically feasible methods for reducing emissions by available technology. The contractor will recommend detailed research and development programs that will lead to control device systems and new air-pollution-free processes for thermal destruction or conversion of refuse. Much operating, engineering, control, and cost information on incineration of immediate value to municipal officials will also be assembled and cataloged.

Aerojet-General Corporation and subcontractor specialists are assessing present and projected quantity, composition, and combustion characteristics of municipal refuse and evaluating applicable boiler and power-generating technology to determine the technical and economic feasibility of utilizing refuse as a low-sulfur

fuel for central power stations. Aerojet will intensively analyze the performance and costs of advanced European installations that emit very little air pollution and will prepare preliminary engineering design of several types of installations. This study will provide detailed plans optimizing future resource allocation for development and demonstration of new and improved processes.

Another systems study now being developed will be directed toward analysis and control of air pollution resulting from thermal destruction of industrial and agricultural wastes. Disposal of these wastes involves consideration of many different requirements related to physical form, composition, point of origin, and economic factors. Methods suitable to various capacities, locations, and types of waste must be developed, along with associated control systems. Another study will evaluate the application of all gas-phase incineration methods to odor and pollution control.

In-house work is continuing on emission sampling techniques and equipment, evaluation of low-cost pit incinerators, and potential emissions that will result from the rapidly increasing plastic content of refuse. NAPCA incineration control studies are coordinated with related studies conducted by other Federal units to ensure information exchange and optimum solution to the problem of air pollution from refuse disposal.

6. Device Improvement Studies. Typically, problems of air pollution control have been approached by modifying and adapting existing processes and control devices for the control of specific air pollution problems. In many other cases, however, this approach is inadequate because of the inherent limitations of some processes and control equipment. An example is the inability of cyclones and scrubbers to collect the fraction of particulate pollution made up of very small particles. Contracts to

study the capabilities and limitations of each major type of existing control equipment, including fabric filters, scrubbers, precipitators, and afterburners, are being negotiated. In addition to present usage practices, the degree of control in terms of properties of particular pollutants will be characterized. The body of knowledge relating to each control device will be assembled, and the capability of the device for controlling specific air pollution problems will be defined. Against the background of this information, a research and development program in each problem area will be developed to expand the capabilities of each control device and permit its extension to the control of new air pollution problems.

Of the available particulate control methods, fabric filtration seems to have the greatest potential for controlling small-particle-size emissions. Owens-Corning Fiberglas Corporation is doing pilot studies and Air Preheater with Public Health Service of New Jersey is doing field studies to investigate the potential of fabric filters as chemical contactors for reacting gaseous pollutants such as sulfur dioxide and fluorides with solid reactants. In-house research of fabric filters has been accelerated as part of a program to develop this control technology.

B. Meteorological Research

The atmosphere's dilution capacity is enormous; however, when man overloads the air at the wrong time, in the wrong place, or with the wrong material, air pollution problems arise. Since the movement and dilution of airborne particles and gases are governed in large part by the motions of the atmosphere, the answers to questions of what constitutes the wrong time, the wrong place, or the wrong materials often require the assessment of an atmospheric scientist.

To help answer these questions, a better understanding is required of atmospheric transport, diffusion, and deposition processes which define an air pollution potential condition. The studies of these processes and of the effects of atmospheric motions on airborne pollutants are frequently categorized as air pollution meteorology or atmospheric diffusion.

Basic goals of the National Air Pollution Control Administration's Meteorology Program determine two distinct types of activities in air pollution meteorology: (1) research, to define and describe meteorological factors pertinent to air pollution control activities; and (2) application of meteorological principles to the conduct of air pollution control programs.

1. Air Pollution Potential Forecasting. The transfer of the Air Pollution Potential Forecasting Program to the Weather Bureau's National Meteorological Center (NMC), Environmental Science Services Administration, in the summer of 1967, marked the culmination of a successful seven-year research and development effort to forecast air pollution potential. Following this transfer of operational forecast responsibility to ESSA, NAPCA's meteorologists have maintained a close liaison with NMC in their efforts to quantify the air pollution potential forecast. Initial attempts to employ a simple box model are based on mixing depth (the height of the air layer above the ground in which pollutants effectively mix) and the average wind speed through the mixing depth, to yield an average normalized pollutant concentration. The mixing depth concept is most applicable in regions of light winds (stagnation) and, fortunately, it is in such regions that forecasts of mixing depth and wind speed are best verified.

2. Large Power Plant Effluent Study. A comprehensive investigation of the transport and dispersion of plumes from tall stacks was initiated at a coal burning power station complex in western Pennsylvania. Each of three power stations having tall stacks over 800 feet high located on a line essentially 25 miles long, will emit daily more than 2000

tons of sulfur dioxide gas into the atmosphere. To assess the potential effects of the airborne effluents from these plants on the surrounding environment, measurements of plume rise, plume geometry, dispersion, and SO_2 concentrations have been obtained, using instrumented helicopters and a mobile lidar (laser-radar), both under contract. These studies are providing information that is being analyzed (a) to develop and validate transport and diffusion models which give calculations of expected ground-level concentrations of effluents from large power plants, (b) to observe the magnitude, frequency, and spatial distribution of ground-level pollutant concentrations from large power plants and tall stacks, and (c) to evaluate the deleterious effects on vegetation of sulfur compounds and other effluents from a large power plant complex in the region of the installations. A similar study of tall stack diffusion at a coastal site is being considered.

3. Boundary Layer Dynamics. The effort to develop and improve urban diffusion models has continued by attempting to describe in more detail urban diffusion processes and to understand the structure of the atmosphere over urban areas. Field investigations of the urban heat island, conducted during nocturnal stable periods in Cincinnati, have shown a pronounced modification of the vertical temperature and wind structure by the underlying urban complex. To study the atmospheric structure over a city located in less complicated terrain, a series of field investigations were recently carried out in Columbus, Ohio; similar investigations will be carried out under selected meteorological conditions. Measurements in Cincinnati of atmospheric turbidity (degree of transparency of a cloud-free atmosphere), an indicator of the aerosol content of the atmosphere, have indicated that the total number of particles

suspended in the atmosphere is less in winter, with a higher proportion of large particles, than in summer. Measurements of ultra violet (uv) radiation in Cincinnati show a marked reduction of uv received at the ground on days of heavy air pollution. The radiation and turbidity measurements at other locations in the country constitute a continuing program to assess the long-term effects of air pollution on the weather; for each respective location, such measurements provide useful data for assessing local air quality and its relationship to meteorological processes.

4. Climatology. Tabulations by the National Weather Records Center, ESSA, of morning and afternoon mixing depths and average wind speed through each corresponding depth, have been prepared for 62 Weather Bureau radiosonde stations; these data are being analyzed to prepare an air pollution potential climatology of the contiguous States, including a frequency of episodes of high air pollution potential, or "stagnation episodes," when shallow mixing depths and light wind speeds persist for at least two days. A geographical delineation and climatological description of areas for the states of Alaska and Hawaii, as well as the islands of Guam, Samoa, Puerto Rico, and the Virgin Islands has been provided; these areas represent a region of dilution climate homogeneity based on professional judgment and documented meteorological statistics. Meteorological descriptions of four air quality control regions provided estimates of the geographical distribution of mean summer, winter, and annual ground-level concentrations of SO_x, CO, and suspended particulates, based on pollutant source inventories provided by NAPCA's Air Quality and Emission Data Program.

C. Health Effects Research

A summary of the most recent findings from health effects studies is presented with additional comments concerning the present research endeavors that serve as extentions of these findings and which are designed to produce information which may be directly applied toward the development of meaningful air quality criteria.

1. Nitrogen Dioxide. One important area of research relates to the definition of nitrogen dioxide as an environmental factor in the etiology of emphysema. It has been shown that cigarette smoking and/or the breathing of polluted air or smog appeared to predispose susceptible individuals to emphysema. High concentrations of NO_2 have been shown to cause severe acute diseases of the lungs. Through the efforts of a number of laboratories, emphysema has been produced experimentally in a variety of animals (dog, monkey, rabbit, rat, and mouse). Initial experiments utilized acutely toxic concentrations of NO_2 to induce subsequent pathology but recent studies have employed a low enough range of concentrations so that the experimental animals survived their natural life spans with minimal evidence of exposure to NO_2. Concentrations as low as 2 ppm of NO_2 administered over the natural lifespan of the rat (2-3 years) have revealed evidence of lung pathology similar to the early stages of emphysema. Such levels approximate the ambient concentrations observed during air pollution episodes. The primate is now being utilized by investigators due to its much longer life expectancy than the rat so that the influence of environmental factors may be prolonged as is most likely the case in man.

2. Nitrogen Dioxide and Ozone. Significant findings relating to nitrogen dioxide and ozone exposures concern the increased susceptibility to pulmonary infections. Earlier studies revealed that 0.5 ppm NO_2 and 0.08 ppm of ozone enhanced the susceptibility of mice to a reapiratory infectivity challenge. Recent work indicates that the enhanced infectivity is not due merely to an impairment of the lung clearance mechanisms (cilia, mucus, phagocytosis), but also due to alterations of the lung parenchyma, per se. These laboratory studies are highly significant since they have implicated a possible relationship between air pollutants and changes in resistance to respiratory infection. These biological parameters can now be tested under ambient situations using epidemiological techniques and utilizing human population groups. Future laboratory studies will concern secondary factors which play a role in the causation of infectious disease. Exposure to cold, extreme fatigue, disturbance in the nutritional state, existence of previous diseases, and many other conditions are frequently significant in the establishment of the disease state. Such predisposing causes comprise the factors in the multiple causality principle and although their importance is well established, their relative contributions in the presence of air pollutants has yet to be quantitatively defined.

3. Oxidants. Increased importance has been given the problem concerning research into the biochemical effects of oxidant air pollutants. Previously, a number of studies have demonstrated short-term effects of ambient levels of oxidant pollutants on biological

parameters such as pulmonary mechanics, oxygen consumption, athletic ability, and others. Recent biochemical investigations of the cellular effects of oxidant air pollutants have produced information which may prove pertinent in the determination of long-term human health effects. Lipid peroxidation is being considered as a mechanism of biological damage from the exposure to oxidant air pollutants. Recent evidence has indicated lipid peroxidation in the lung lipids of rats exposed to 1 ppm NO_2 for four hours. The peroxidative changes did not occur immediately but appeared to reach a maximum level between 24 and 48 hours post-exposure. This effect could be partially prevented by the prior administration to the animals of large doses of the antioxidant, alpha-tocopherol. Pulmonary surfactant obtained from rats exposed continuously to 1 ppm NO_2 for two weeks contained increased quantities of phosphotidylcholine with a concommitant decrease in phosphotidylethanolamine, an important precursor for phosphotidylcholine. Corresponding increases were observed in palmitic acid content with decreases in the long-chain polyunsaturated fatty acids. These changes reflect the observed increase in phosphotidylcholine and the peroxidation of the normally present unsaturated fatty acids. These findings are considered significant since they represent basic changes at the cellular level and result from exposures of biological systems to low levels of air pollution. Additional studies, presently in progress, and concerning the biochemistry of the lipid portion of pulmonary surfactant will allow conclusions to be drawn as to the effect on the metabolism of surfactant lipids by these air pollutants and the mechanism by which such changes may contribute to the

subsequent development of physiological abberrations.

4. Particulate Matter. It has been known for many years that chemical substances of a carcinogenic nature are present in particulate air pollutants. These substances have been shown to be cancer enducing when painted onto the backs or injected into the skin of mice. However, when these same substances were injected into the lungs of experimental animals the results did not indicate the production of cancers with any regularity. The interaction of carcinogens with other particulate agents has been studied toxicologically utilizing laboratory animals. Experiments have shown that the addition of seemingly inert particulates to carcinogens results in the production of malignant neoplasms in the lung. Various experiments have produced a variety of malignant tumors in the lungs of experimental animals by intratracheal instillation of saline suspensions of benzo(a)pyrene (BaP) in the presence of particulate substance serving as a carrier dust. It has been inferred that there is a reduction in the speed in which BaP is removed from the respiratory tract brought about by the particulate dust. Recently, researchers have demonstrated the interaction of a known carcinogen with the gaseous air pollutant, sulfur dioxide. Inhalation exposures of rats indicated that SO_2, alone, produced proliferative and metaplastic changes in the bronchial epithelium; BaP, alone, failed to cause the development of tumors; but the inhalation of BaP in the presence of SO_2 caused the development of bronchogenic squamous cell carcinoma. Other studies have employed the injection of crude benzene-soluble extracts of atmospheric particulate into suckling mice.

At 50 weeks post-inoculation, a variety of tumors were evident, the most significant being lymphomas, hepatomas, and multiple pulmonary adenomas. It should be noted also that measurable concentrations of inorganic substances, such as metal dusts and asbestos, demonstrated to be associated with increased liability to lung cancer development, are also emitted into the atmosphere. Additional laboratory experimentation is needed to verify such carcinogenic potential relative to interacting effects and respective ambient atmospheric concentrations. When linked with urban-rural differences in lung cancer frequency revealed from epidemiologic investigations, this evidence indicates that such substances in urban polluted atmospheres are potential carcinogens for the exposed human population.

5. Carbon Monoxide. Carbon monoxide is highly suspected as one of the environmental predisposers to myocardial infarcts and a potentiator of morbidity and mortality from this phenomena. Experiments have demonstrated that dogs exposed to CO had decreased arterial-veneous oxygen differences in spite of an increased coronary blood flow. Additional studies, utilizing humans with coronary heart disease, have shown that COHb levels between 5 and 12 percent resulted in a decreased oxygen myocardial extraction, which was related inversely to the COHb levels, despite an increased coronary flow and heart output. Such observations have shed light on the observed higher incidence of coronary thrombosis in smokers versus non-smokers.

6. Behavioral Toxicology. There has been increased interest and support for Behavioral Toxicology which is an area of research for determining how toxic compounds affect systems and alter the normal response of an individual or experimental animal. Very low dosages of certain compounds can meaningfully alter the behavior of people without causing any conscious or apparent physiological distress or tissue damage. Studies are in progress to determine how information is processed in the brains of rats and monkeys and how certain pollutants change this processing. Three general areas are concerned: (1) neuro-chemistry, for determining how pollutants interfere with chemicals such as serotonin, acetylcholine, and noradrenline, which are responsible for transmission of electrical signals in the brain; (2) neuro-physiology, or more precisely electro-physiology, which is being studied in relation to electrical activity in the visual cortex and in the superior colliculus, which controls the visual motor system; and (3) behavior--this is being investigated in relation to timing sense, problem solving, and decision making. The final integrated effort concerns how air pollutants affect the whole animal organism. This will involve the recording of a variety of physiological responses--body temperature, EEG, EKG, and respiratory gases--while simultaneously controlling and evaluating how the animal copes with increasingly complex decisions and performance tasks. To date, the effect of carbon monoxide on the electrical activity of the brain has been investigated through studies of the brain's response to a visual stimulus. The visual stimulus evokes a characteristic

electrical response in the visual area of the brain. The wave form of this response is changed following the inhalation of carbon monoxide (100 ppm CO for two hours). In general, both the amplitude and the harmonic content of the brain's response to a visual stimulus are decreased with CO exposures. Other studies have concerned the effects of chronic lead absorption on the spontaneous EEG sleep records of rats and the relationship of such responses to behavior changes. Since sleep tends to follow orderly patterns, related changes are relatively easy to detect. This research has indicated that lead changes the period of deep, or dream, sleep, shortening the period and making it less stable. Treated animals showed more dream sleep in the early sleep period as compared to baseline data; in addition, the patterns of deep sleep became less regular. These changes in dream sleep are considered to directly, or indirectly, reflect the impairment of a neuro-control system. Altered functions of the central nervous system may be evident before clinical signs and symptoms have been induced by exposure to toxic materials. In particular, the changes in dream sleep may involve the mechanism responsible for controlling transitions between the various levels of consciousness. This may be related to the sluggishness associated with exposure to lead and other toxic metals. The underlying importance of this program is to discover what stressors in the environment may make it more difficult for people to perform efficiently at given tasks.

7. Epidemiologic Studies. In an epidemiologic study of 450 second-grade elementary schoolchildren in the Cincinnati area, the pulmonary function of the children living in the more polluted sectors of the city was persistently below the pulmonary function of children, matched for social economic level and race, living in a "clean" sector of the city. This difference was consistent during weekly measurements obtained in November 1967 and February and May 1968, and was present in the face of only a 20 percent difference in average exposure of the two groups to particulate air pollutants.

One thousand second-grade schoolchildren from Greater Chattanooga have been enrolled in a similar epidemiologic study designed to ascertain the effects of exposure to oxides of nitrogen on pulmonary function and on the frequency and severity of acute respiratory disease. Weekly pulmonary function tests were obtained during November 1968 and will again be obtained in March 1969. The households of the children are being questioned at biweekly intervals regarding the presence and severity of acute respiratory diseases.

The city of Saratoga Springs, New York, was intensively sampled by means of 40 intermittent roto-bar samplers during the August-September 1968 ragweed season, in order to determine the distribution of pollen concentration in a community. These data are being used to plan a subsequent six-city epidemiologic study in New York state of the effect of ragweed control on hayfever prevalence.

Outbreaks of asthma in epidemic proportions have occurred annually during the months of September, October, and November in New Orleans for the past 15-20 years. These outbreaks have been

analyzed for the 1960-67 period and have been found to be associated with low temperature and humidity recordings during those months, but do not appear to be related to increases in specific chemical pollutants. Studies are continuing to determine the additional relationship of the asthma outbreaks to concentrations of aeroallergens.

A preliminary study of the effect of riding in taxicabs on breath concentrations of carbon monoxide revealed that both smokers and non-smokers have elevated breath carbon monoxide concentrations after riding through a normal traffic pattern in taxicabs for three to five hours. Although cigarette smokers have the highest persistent carbon monoxide levels, the percentage increase of carbon monoxide was greatest in the non-smokers on exposure to carbon monoxide by normal taxicab riding.

Cadmium concentrations in dustfall, water, and milk were measured in 70 metropolitan areas in mid-continental states during the months of September and October 1968. These data will be related to variations in cardiovascular disease mortality in 70 cities.

Initial contacts have been made to establish an air pollution-health effects surveillance network in selected cities of the United States. Through this network, the effect on selected indices of health will be related to the changing air quality within each city and to differences in air quality between the cities. The effect of differences in air quality on school and industrial absences, hospital admissions for selected diseases, severity of respiratory

disease epidemics such as influenza, and on other measures of health will be analyzed in this surveillance study.

D. Economic Studies of Air Pollution

Until recently, the economic effects of air pollution and the cost of its control were largely unexplored areas. Virtually all that has been done in studying and analyzing the economic aspects of air pollution has been initiated since the passage of the Clean Air Act of 1963. At first, these efforts were viewed as only an incidental part of the NAPCA's responsibility. However, economic studies are now recognized as a strategic part of the overall effort to develop and disseminate information on the effects of air pollution and its control. Information on costs and benefits will be important to both public and private decision makers in upcoming periods.

Several studies of the benefits associated with air pollution control have been undertaken and completed. They include estimates of additional expenditures to avoid soiling, reductions in property value, damages to commercial vegetation, and costs of human mortality and morbidity. For the most part, these studies have been specific to particular times and particular geographic locations and, therefore, are not readily generalized to other times and places. Moreover, the methods by which most have been conducted are open to some question.

To meet the need for reliable, useful economic information, NAPCA is presently conducting studies to (a) secure basic data on the damage air pollution causes to vegetation, livestock, and materials; (b) determine the cost of controlling air pollution emissions; and

(c) analyze the overall economic impact of air pollution control in order to appraise the State, local, regional, and national economic burdens. Brief summaries of some of the major studies underway or planned in these areas are presented.

1. Vegetation Effects. Several species of economically important plants are being exposed to gaseous pollutants such as ozone and sulfur dioxide in order to determine the sensitivities of different species and varieties and to eventually develop dose-response curves which will be useful in the setting of air quality criteria. In addition, laboratory studies are being conducted to determine how variations in environmental factors such as light, humidity, temperature, and a variety of soil variables affect the sensitivity of various plant species to specific pollutants.

In the summer of 1968, experimental field studies were begun to determine the effects of ambient air pollutants on the growth and yield of several common species and varieties of field and garden crops. These studies will be expanded to include additional species during fiscal year 1970. In cooperation with the U.S. Forest Service, a field study was begun in 1968 to determine the feasibility of using color and color-infrared aerial photography for the detection of oxidant damage to ponderosa pine in California. This study will be expanded to include other multispectral sensing devices in the spring of 1969.

To assess the agricultural effects of air pollutants, the Administration works closely with the U.S. Department of Agriculture as part of a coordinated and cooperative program.

2. Effects on Materials. Chamber studies are being conducted in order to quantitatively establish cause-effect relationships between the fading of 20 selected fabric-dye combinations and controlled parameters--gaseous pollutants, relative humidity, and temperature. Studies are going on at five sites in the area of Birmingham, Alabama, to relate the concentration of particulate matter and other pollutants to the soiling of windows, painted panels, and other building materials. The National Bureau of Standards in cooperation with NAPCA is studying the effects of sulfur dioxide and photochemical oxidants on a variety of building materials. In addition, a contract has been negotiated to identify air pollution problems of economic significance in the damage to electrical contacts such as connections and switches used in industrial electronic and electrical systems. A similar contract has been made to identify air pollution problem areas in the entire field of textiles including fabric and fiber deterioration, dye-fading, and soiling.

3. Socio-Economic Effects. Results of a recently completed cross-sectional study of the effects of air pollution on residential real estate values indicates an inverse relationship between air pollutant concentration and property values. This study will be extended to cover other metropolitan areas in the near future. In January 1969 a study will be initiated to determine the nature and magnitude of odor problems on a national scale and to study specific community odor situations in order to develop air quality criteria for various categories of odorants. Further field studies to assess soiling damage costs and socio-economic impact of visibility reduction will also be initiated in fiscal year 1969.

4. Emission Control Cost. The cost of reducing air pollutant source emissions is being evaluated through detailed industrial surveys, by general pollutant categories, and by generic types of control equipment. Each of these investigations is designed to compliment and refine the others. Where possible, cooperative studies are being undertaken with industrial groups and other Government agencies to develop accurate cost-effectiveness relationships and to predict future air pollution control costs. These cooperative efforts have been quite productive in developing interest, knowledge, and concern through involvement of the participants. Data collection has been completed on three industries--the steam-electric power generating industry (in cooperation with the Federal Power Commission), the gray and ductile iron foundry industry (with the Department of Commerce), and the asphaltic concrete industry. The data are being analyzed and separate reports on the findings of each study are in preparation.

Systems studies which include the assessment of air pollution control costs are being conducted by contract in the integrated iron and steel industry and the wood pulping industry. Similar studies are being developed in the acid manufacturing and the petroleum refining industry.

A cooperative study of control cost with the cement industry is under development. This study will include projection of control costs into the future by each industrial firm.

Research is underway to establish the cost of controlling emissions of specific pollutant categories by generic types of control equipment or by fuel and material substitutions. Such cost-effectiveness analyses have been completed for particulates and oxides of sulfur and have been included in the control technology documents which accompany the air quality criteria documents discussed elsewhere in this report. Similar investigations are underway for carbon monoxide, oxides of nitrogen, and hydrocarbon compounds.

Procedures and techniques for making regional and national assessments of control costs are being developed. These techniques are to be implemented in air quality control region analyses as authorized in the Air Quality Act of 1967. Such techniques are being designed, evaluated, and refined in a Philadelphia Metropolitan Area Study under development. The methodology for these urban analyses shall employ and expand the computerized techniques of determining the least cost methods of meeting air quality standards that have been developed in simulation studies within NAPCA.

5. Economic Impact of Standards. Progress is being made in economic analysis of National Emission Standards as required by the Air Quality Act, Section 211(a). The industrial categories to be considered have tentatively been selected and the analysis procedure has been outlined. The necessary industry statistics and related costs information for other studies are being assembled for such economic evaluations.

The NAPCA is continuing to sponsor comprehensive cost-benefit studies and systems-type regional and national analyses which take

into consideration both the cost of reducing pollution emissions and the resulting receptor effects of these emissions. Present cost studies are designed to refine the data inputs to these large, more comprehensive cost studies.

A comprehensive study has been completed of the national impact of the provisions authorized by the Act. A report on this study has been prepared which contains a detailed estimate of such costs for the five-year period beginning July 1, 1969, and shall be updated annually thereafter.

In addition to its own studies, NAPCA is actively encouraging independent investigations by industry, universities, and other public and private groups through participation in conferences, seminars, and other special meetings.

III. CONTROL PROGRAM SUPPORT

A. Control Agency Development Program

The rising national concern with air pollution is evidenced by the increased control activity of State and local governmental agencies. In part, this growth can be attributed to the financial incentives and technical assistance provided by the Clean Air Act. State and local governments are now spending approximately $50 million a year, including Federal funds, for control programs as contrasted with approximately $12 million prior to enactment of the Act in 1963.

1. Federal Grant Support. Grant support is currently going to an estimated 175 State, regional, and local agencies. While a number of new agencies qualify for assistance each year, others which have formerly received assistance fail to qualify for continued support, largely because of failure to enact the necessary control legislation or for lack of non-Federal matching funds.

It is expected that the number of agencies operating control programs will not increase as rapidly in the future as they have in the past four years. This can be attributed to a consolidation of agencies serving adjacent jurisdictions, such as the joint Wayne County-Detroit, Michigan program, and to the current existence of control programs in the bulk of the populated areas.

The establishment of air quality control regions will also influence the organization of multi-jurisdictional agencies, but the degree to which this will occur cannot be foreseen at this time. At present, 58 municipal or regional agencies in 28 of the 32 regions

to be designated are receiving Federal grant support. Regions not now receiving such support are Providence, Rhode Island; Baltimore, Maryland; Birmingham, Alabama; and Chattanooga, Tennessee. In addition to local programs, State agencies provide varying levels of services to the local areas, and, in the case of Providence, Rhode Island, the State agency is the exclusive control agency under provisions of State law. At present, 22 State agencies involved in 28 of the air quality control regions are receiving Federal air pollution control program grants.

2. Maintenance Grants. The first report indicated that maintenance grants were expected to be awarded during 1968 fiscal year. Since that time 10 agencies have qualified for and have received maintenance grant support. Equally significant is the fact that more than half of the applications received have been disapproved, pointing up the very serious gaps in some of the operating programs considered among the better ones in the country. In the course of the application review process, consultation with the agencies has resulted in program redirection on the part of the applicant agencies in order to bring their individual programs up to the standards set forth in the Regulations.

3. Technical Assistance. Consultation provided in the course of grant application review is only one facet of the broad technical assistance provided to State, regional, and local agencies by NAPCA. Visits by teams of technical staff members for the purpose of program

review are also provided. A recent example is the city of Cleveland, Ohio, where at the request of the Mayor the city's control program was evaluated and recommendations were made for strengthening it.

Members of the diversified technical staff also provide assistance on specific problems such as review of proposed ordinances, laboratory and monitoring methods, and control methods for specific pollutants. An estimated 120 requests were serviced in the past year, and significantly, 12 were from the core cities in the first 20 air quality control regions planned to be designated.

4. Survey and Demonstration Grants. Survey and demonstration projects supported within the past year give some indication of the broad range of problems for which solutions are being sought through the grants program. A listing of the projects follows:

Illinois Air Pollution Commission. A survey of the availability of low sulfur coal in the Midwest coal fields and development of economic data on its production and distribution.

Computer Graphics Laboratory, Harvard University. A demonstration of computer mapping techniques for producing graphical displays of various types of information utilized in the prevention and control of air pollution.

Ohio Department of Natural Resources. A survey of the availability of low sulfur coal in the deeper portions of the Ohio coal seams, with data obtained from analyses of drill cores.

Chicago Department of Air Pollution Control - To develop an SO_2 incident forecasting system and control policy and strategy, and to produce and publish an operations manual which would enable other communities to employ similar principles.

Philadelphia Health Department (in cooperation with Pennsylvania State Health Department)- To develop information on steps which can be taken, by industry classes, to reduce pollution during emergency alerts and to evaluate the effects of such steps on the atmosphere and their impact on the community.

California Air Resources Board - A study of the feasibility of control of NO_x emissions performed on a test fleet of 120 State operated motor vehicles.

California Air Resources Board - Continued support for diesel smoke measurement on a dynamometer installation at a highway truck inspection station.

New Jersey Health Department - A continuation of the project for developing rapid emission test procedures for use in State inspection lanes. Involves equipping pilot lanes and testing the prototype system under actual operating conditions, and determining effectiveness of maintenance performed by private garages servicing cars which fail hypothetical State standards.

All of these activites--financial support, technical assistance, and the search for new or better solutions--are directed toward strengthening State, local, and especially regional control programs.

B. Research Grants Program

The research grants program of NAPCA offers a continuing source of basic research knowledge needed to implement the purpose and intent of the Air Quality Act of 1967. It provides basic, developmental, and applied research information which supplements inhouse and contract research in the areas of cause, effect, prevention, and control of air pollution with respect to human health, welfare, and productivity. The purpose of the program is to promote and encourage research and development of basic theories, new concepts, methods, and equipment for the establishment of air pollution standards and more effective air pollution control.

1. Research Grant Projects. In FY 1968 there were 207 active research grant projects totaling $7,431,000. These projects contributed needed basic knowledge to the following areas of research:

a.	Air pollution effects on human health	30 grants
b.	Agricultural effects of air pollution	28 grants
c.	Economic and political studies	9 grants
d.	Analysis and physiochemical investigations	49 grants
e.	Development of analytic methods and equipment	21 grants
f.	Meteorology	20 grants
g.	Identification of air pollution sources and control	42 grants
h.	Communication	8 grants

2. Operational Aspects. The research grants program is guided by the recommendations of extramural advisory groups and the opinions of intramural researchers. Decisions are made to select and fund only the best, program-relevant research grant projects. Also by this

method, certain areas of fundamental research which need additional emphasis and which lend themselves to support by research grants have been identified. These areas are: behavioral toxicology, quantitative pathology of respiratory systems, biochemistry of the toxicity of oxidative pollutants, new physical concepts for air pollution instrumentation, life cycles of important pollutants, public attitudes and acceptance of esthetic insults, and the relationship between air pollution damage and market parameters. Programming activities are being directed toward increasing the number of projects in these research categories.

Recently a program of exploratory grants to encourage new investigators to enter the air pollution field and to provide a way to increase research in areas neglected by regular research grants has been initiated. These grants provide limited support for feasibility studies by young investigators who have stimulating ideas but limited background of research experience. It is anticipated that approximately 150 applications for exploratory grants will be received in FY 1969; however, because of the dearth of funds, only a few will be awarded.

During the past year activity has increased in program analysis to bring together and make readily available the information gained through research under the grants program. A "highlights" booklet listing abstracts of recent research findings has been prepared for publication. Another booklet, being readied for publication, will list the scientific and technical papers and reports which have

resulted from research grant projects so that investigators will have, in one publication, a complete reference to the research carried on by other investigators in the grants program.

C. Relationships with State and Local Officials

NAPCA has developed a variety of relationships with associations of elected and appointed officials at all levels of government in an effort to insure the most effective coordination of governmental responsibilities and authorities. Among the organizations with which NAPCA has developed strong working relationships are the National Association of Counties, the National League of Cities, their Service to Regional Councils, the Association of State and Territorial Health Officers, the Governors' Conference, and the Council of State Governments.

These relationships serve a very valuable communications function in the effort to improve the quality of the Nation's air. NAPCA advises these organizations of matters within their areas of responsibilities and of likely effects of specific NAPCA programs on each particular level of government. The associations of governmental officials respond by advising NAPCA of problems they see, of alternative methods of implementing programs and of the perspectives with which their constituents view specific NAPCA policies. As implementation of the Air Quality Act of 1967 continues, this communications function should prove to be increasingly valuable.

IV. PROGRESS TOWARD A REGIONAL APPROACH TO AIR POLLUTION

A. Definition of Atmospheric Areas

On January 16, 1968, the definition of Atmospheric Areas for the contiguous United States was announced in the Federal Register. The basis for the definition was discussed in the first progress report. Those areas not included in the initial notice were completed and announced in the Federal Register on November 13, 1968. Atmospheric areas were defined for Alaska, Hawaii, Guam, American Samoa, Puerto Rico, and the Virgin Islands. This completes the action required under Section 107(a)(1). Atmospheric Areas have now been defined for all portions of the United States.

B. Designation of Air Quality Control Regions

The process of developing and designating air quality control regions has followed closely the procedure outlined in the first progress report. Attempts have been made, however, to improve on the procedure through extensive communication with affected State and local authorities. Such extensive communication is designed to make the consultation with these authorities, prior to designation, a meaningful exchange of views within the framework of cooperative Federalism.

Thus, the evaluation of engineering and urban factors, which NAPCA considers in the preliminary determination of tentative boundaries, is made available in report form prior to the Consultation. These reports are available to the general public, but their primary purpose is to provide the affected State and local officials with a detailed outline of NAPCA's view of the problem area. Reports are prepared in

such a manner as to highlight the approach of the Air Quality Act--an assessment of both technical and jurisdictional aspects, recognizing the dynamic nature of the problem and the attempts to control present and future air pollution.

Much effort is expended to inform State and local officials of NAPCA's position, both before and after the formation of the report. Several meetings with State officials are held to discuss the responsibilities of State action under the Air Quality Act. Local control officials are consulted to contribute their expertise. Once the report is completed, letters are sent to appropriate State and local officials, a cross-section of Federal officials, and members of other executive Departments. These letters inform the officials of the Consultation, and provide them with a copy of the report for their perusal. A notice of proposed rule making is published in the Federal Register, giving the time, date, and place of the formal consultation, along with the proposed boundaries of the air quality control region. The formal Consultation is open to the public, but since the Act specifies that this is to be consultation with "appropriate State and local authorites," participation in the Consultation is limited to such officials. Written comments from the general public are accepted within a thirty-day period after publication in the Federal Register, and receive close scrutiny prior to the final recommendation. A press release is timed to coincide with the Federal Register announcement, so as to provide increased publicity of the proceedings.

The Consultation is conducted under the direction of a chairman designated in the Federal Register announcement. The proceedings are transcribed, and use is made of these records in preparing the final proposal. The formal Consultation held in this manner has proven to be useful in achieving public understanding and governmental cooperation. While the views expressed at such Consultations may not always be expected to give unanimous approval of NAPCA's action, a high degree of consensus on region boundaries has been achieved. The formal Consultations have indicated that full and adequate cooperation is possible, as envisioned in the Air Quality Act, among State, local, and Federal authorities.

Activities in this field have begun to culminate in the designation of regions. Air quality control regions are designated through republication in the Federal Register, by the Secretary of the Department of Health, Education, and Welfare, of the proposed boundaries, allowing for any changes that may have taken place during the period of consultation. Regions have been designated in the metropolitan areas surrounding Washington, D.C., New York City, Chicago, and Philadelphia. Consultations have been held in Denver and Los Angeles.

Air quality control regions proposed by NAPCA do not become official until the Secretary's republication in the Federal Register.

Technical assistance is to be provided to the designated air quality control regions by appropriate NAPCA staff personnel assigned to the regions. This assistance will be available to States and local agencies for technical guidance as well as for the acquisition

of necessary information for proposing standards and implementation plans. Actual evaluation of proposed standards and implementation plans will also be provided by NAPCA staff.

C. Development of Air Quality Criteria

During the reporting period, air quality criteria documents on two major pollutants, particulate matter and the oxides of sulfur, were prepared in preliminary form. These documents are to be published and issued to the States in early 1969. Progress was made in the development of several other major pollutants, namely, photochemical oxidants, carbon monoxide, atmospheric fluorides, hydrocarbons, and the oxides of nitrogen. Other pollutants for which the development of criteria is under consideration include aldehydes, asbestos, beryllium, certain heavy metals, ethylene, hydrogen sulfide, lead, odors, organic carcinogens, pesticides, and rocket fuel components and their combustion products. Priority of development of criteria for these pollutants will depend on several factors, the main factor being the results of a study presently underway to exhaustively survey available information on the pollutants involved. This study is expected to define the magnitude and seriousness of the problems associated with each of these pollutants or category of pollutants, as well as with others not listed here. The establishment of a priority list for development of criteria will then be undertaken. Assistance in this effort will be provided by the National Air Quality Criteria Advisory Committee. Summary discussions of the two criteria documents soon to be issued follow.

1. Particulate Matter. Work began in the summer of 1967 on the preparation of a document on air quality criteria for atmospheric particulate matter and extended to December 1968. A working draft was produced in October 1968. This draft reflected the efforts of several NAPCA staff members and university consultants working under contract. The draft was subjected to an elaborate and intensive review by the Air Quality Advisory Committee's Subcommittee on Particulate Matter, the full Advisory Committee, chapter authors, special consultants, NAPCA staff, and sixteen other Federal agencies. Incorporation of review comments resulted in several subsequent drafts prior to finalization of the preliminary statement issued in December 1968.

The document focuses on background information and effects at various particulate concentrations. Effects on vegetation, materials, animals, and human health are stressed, along with effects on visibility. Certain effects are observed at concentrations ranging from about $80 \mu g/m^3$ to $200 \mu g/m^3$. Both sensitivity to the presence of particulate matter by the population and effects appear to vary in direct proportion to concentration.

2. Sulfur Oxides. The document on air quality criteria for sulfur oxides supercedes a similarly entitled document published in March 1967. The later document, also to be published in early 1969, represents a reevaluation and interpretation of information contained in the earlier version plus a consideration of pertinent material published after the first document was prepared. Primary authorship of both documents rests with NAPCA staff members, although advice

and consultation were obtained from consultants and others outside of NAPCA. The final published document will reflect an intensive review by many of the same reviewers for the document on particulate matter.

As is the case with the particulate matter document, the sulfur oxides criteria document focuses on background information and effects at various concentrations.

D. Development of Information on Available Control Techniques

As companions to the air quality criteria documents on particulate matter and sulfur oxides, documents on control technology for the same pollutants will be published as part of the overall coordinated program of NAPCA. Scheduling was arranged so that the criteria and control technology documents for these two pollutants would follow closely to the dates of the declaration of the first air quality control regions. The currently best known means for controlling the sources of these two pollutants within an air quality region are offered.

The control technology documents are the results of the efforts of NAPCA personnel to compile a comprehensive state-of-the-art report which combines the techniques of control with appropriate cost-effectiveness studies. Critical review by the National Air Pollution Control Techniques Advisory Committee, Federal agency representatives, and representatives of industry enabled a vast amount of experience and knowledge to be incorporated into these documents.

1. Particulate Matter. In the particulate report, the major sources and the various types of pollutants emitted from them are listed, together with descriptions of the applicable but different control systems and techniques. A large portion of the report is devoted to the description of various gas cleaning devices and the technical considerations involved in selecting one for a given process. Among the devices evaluated are gravitational settling chambers, dry centrifugal cyclones, low and high-pressure wet collectors, low and high-voltage electrostatic precipitators, baghouses, and afterburners. A concluding section reviews the current research programs. Both stationary and mobile sources are discussed.

2. Sulfur Oxides. The sulfur oxides document considers both process changes and emission controls. The techniques for controlling sulfurous gases generally involve the combustion of various materials, although separation of sulfur oxides from other products of reaction is often complicated. In the report, sections on location, costs, and availability of low-sulfur fuels, as well as the economics of fuel substitutions and fuel switches, are included. A survey of fuel and flue gas desulfurization techniques in various stages of development is included, presenting full-scale installation feasibility and cost-effectiveness data. Control processes for numerous other industrial processes are described. Tall stack design information is included for use where adequate dispersion of pollutants by this method is acceptable. Current research is reviewed and source test methods, as well as process emissions factors, are given.

3. Other Pollutants. Currently, first draft reports on three additional pollutants--carbon monoxide, nitrogen oxides, and hydrocarbons--are in preparation. Each of the three reports discusses emission sources, describes and evaluates control techniques for mobile and stationary sources and for specific industrial processes, and presents the economics of different control techniques. Proposed future reports on fluorides and odors are in the early stages of planning.

V. FEDERAL ABATEMENT ACTIVITIES

A. Abatement Actions

The Federal abatement authority authorized in the 1963 Clean Air Act is retained in the Air Quality Act of 1967 (Section 108).

To date, the Secretary has convened one intrastate and eight interstate conferences. Three of the interstate conferences were initiated at the request of Governors of States affected by air pollution from out-of-State sources, and five were initiated by the Secretary after consultation with State officials. The one intrastate conference, in Montana, was requested by local officials with the concurrence of the Governor.

Since the first report, one interstate abatement conference was held in the Ironton, Ohio-Huntington, West Virginia-Ashland, Kentucky area. Consultation with pre-conference investigations in the Steubenville, Ohio-Weirton, Wheeling, West Virginia region are now complete. Since this area is expected to be designated as an air quality control region in the near future, the results of abatement investigations will provide a basis on which the State can act under the new regional provisions of the Air Quality Act of 1967.

B. Pollution from Single Sources

Surveillance continued on progress toward meeting recommendations of the Secretary, HEW, in the four smaller areas in which past conferences were held:

Selbyville, Delaware-Bishop, Maryland
Shoreham, Vermont-Ticonderoga, New York
Lewiston, Idaho-Clarkston, Washington
Garrison, Montana

In each case, pollution problems stemmed primarily from single sources. With the exception of the rendering plant in Bishop, Maryland adequate progress has been made, although assessment of improvements is not yet final.

At the request of the Secretary, the U.S. Attorney General brought suit against the Bishop Processing Company plant. The suit was settled with the Bishop Processing Company agreeing to a consent decree after the U.S. District Court Judge upheld the constitutionality of the Clean Air Act in denying the defendant's motion to dismiss. Terms of the consent decree provide that if Delaware health officials declared that pollutants from the Bishop plant reach Delaware a court order may be issued to close the processing plant immediately. The successful conclusion of this case provides an important precedent for Federal abatement action.

C. Metropolitan-Industrial Pollution

As previously noted, an abatement conference was held in the Ironton, Ohio-Huntington, West Virginia-Ashland, Kentucky area. The problem was found to be essentially one of a high level of particulate pollution from industrial sources. The problem is aggravated by the location of sources and receptors in a rather narrow valley. Conference participants agreed to several recommendations for remedial action which have been forwarded to the Secretary, HEW.

A second phase of the Kansas City, Kansas-Kansas City, Missouri abatement conference found that particulate pollution was the central cause of a borderline sulfur oxide problem. Conference participants adopted remedial recommendations for controlling sources of particulate

pollution and for surveillance of sulfur oxide levels. These recommendations were issued by the Secretary in October 1968.

In Parkersburg, West Virginia-Marietta, Ohio it is planned to reconvene the abatement conference to review additional data.

Surveillance activities in cooperation with State and local agencies continued in Metropolitan New York-New Jersey and Washington, D.C. Metropolitan Area.

D. International Joint Commission Studies

NAPCA provides staff support to the International Joint Commission (IJC) in studies of air pollution in the international areas of Detroit, Michigan-Windsor, Ontario and Port Huron, Michigan-Sarnia, Ontario.

This effort is directed by representatives of Canada and the United States sitting on the St. Clair-Detroit Air Pollution Board of the IJC. NAPCA provides staff and support to the U.S. sector of this Board. Field work on both sides of the border has been completed. A report to the Board will be completed by mid-1969.

At the request of the Air Pollution Advisory Board, IJC, three point sources of air pollution on the U.S.-Canada border were inspected by NAPCA representatives on behalf of the U.S. section of this Board. A report to the Board on these sources is in preparation. Further inspections of border air pollution problems will be undertaken as requested by the IJC.

E. Emergency Abatement Measures

The fundamental approach of NAPCA in the implementation of provisions of Section 108(k) of the Air Quality Act is to assist State and local agencies in developing plans for action in the event of high concentrations of air pollutants, i.e., emergency episode planning.

To supplement the work of the NAPCA task group considering this problem, a contractor was hired to develop a state-of-the-art report suitable for use as a planning/action guide for State and local agencies. This work has been completed and after review by NAPCA staff will be published and distributed. This manual identifies those deficiencies in present knowledge and capabilities to respond to emergency situations. Some of these deficiencies will be remedied by ongoing investigations in Chicago and Philadelphia which are supported by NAPCA demonstration grant funds.

Additional contract work being negotiated includes improvement of the planning manual recently produced, development of a planning/action guide for accidental air pollutant release, and development of model legislation.

Work was completed on an assessment of those areas of the country most susceptible to air pollution episodes and the status of emergency action plans in the ten highest potential areas.

This report will enable NAPCA to key its technical support in developing emergency plans to the most critical areas. While support is given through technical and financial assistance to all of these areas, a special effort will be made to stimulate and assist emergency planning in those cities with the highest air pollution potential.

The review and approval mechanism of awarding Federal grants of money continues to assist in stimulating emergency plan development in many control agency programs.

VI. RELATIONSHIPS WITH OTHER FEDERAL PROGRAMS

The National Air Pollution Control Administration conducts and supports most of the Federal Government's research and development work relating to the causes and effects of air pollution and its prevention and control. A number of other Departments and agencies are involved in research and development relating directly or indirectly to air pollution. Support for a major part of the work relating directly to air pollution is furnished by NAPCA through transfer of funds. The total Federal effort includes research and/or development in the biological and medical sciences, economics, engineering, and the physical sciences (including meteorology), and in such areas as public health, agriculture, transportation, conservation of natural resources, fuel use, electric power and urban design. Coordination of such diverse activities is achieved through a variety of mechanisms. These range from informal and formal working relationships between NAPCA and other Federal agencies to interdepartmental committees and ad hoc groups organized for specific purposes.

Approximately $6 million is currently being transferred to other agencies in support of R&D work related to air pollution control. Typical of the agencies with which NAPCA has established working relationships are: Bureau of Mines and Office of Coal Research in the Department of the Interior; Environmental Science Services Administration and National Bureau of Standards in the Department of Commerce; Department of Agriculture; Tennessee Valley Authority; and the Atomic Energy Commission.

There is a special working relationship between NAPCA and the Environmental Science Services Administration. This agency's research on meteorological factors having a direct influence on air pollution levels is conducted in part by meteorologists assigned to NAPCA. Their work is planned jointly with NAPCA staff members. Additional means of coordinating meteorological research and exchanging scientific and program information are provided by various interdepartmental committees operating under the aegis of the Federal Council for Science and Technology and of the Federal Coordinator for Meteorological Services and Supporting Research (the Administrator of the Environmental Science Services Administration). The principle committees dealing with matters relating to air pollution are the Interdepartmental Committee on Atmospheric Sciences and the Interdepartmental Committee on Applied Meteorological Research.

In the area of research and development on control of sulfur oxides pollution, the Stanford Research Institute developed a planning and programming document under contract with NAPCA. This document, after review by the Office of Science and Technology, the Bureau of the Budget, and various Federal departments and agencies engaged in sulfur oxides research, has been made available to Congress and all concerned parties. It is designed to provide not only a comprehensive plan for Federal activities in this area during the next five years, but also a mechanism for systematic coordination of these activities.

The development of advanced power systems concepts is an area of interest to several other Federal agencies. To exchange technical information on this subject and make research and development needs

known to other agencies, NAPCA is a member of the Interagency Advanced Power Group. Other members are the National Aeronautics and Space Administration, various components of the Department of Defense, and the Atomic Energy Commission.

The development of propulsion systems for automobiles is an area in which air pollution factors are of paramount importance, but in which consideration must be given to many other aspects of the relationship between transportation systems and the quality of the urban environment. An interdepartmental group established under the joint auspices of the Bureau of the Budget and the Office of Science and Technology has been considering needs and plans for Federal research and development in this area. NAPCA is a member of this committee, along with constituent agencies of the Departments of Transportation, Commerce, Housing and Urban Development, and Interior. Also, an interagency power plant siting committee is preparing a report under the leadership of OST. Members of this committee are HEW (NAPCA), FPC, AEC, Interior, USDA (REA), and BOB.

Additional examples of interagency working relations are: (a) encouragement of the Federal Power Commission (FPC) to adequately weigh the air pollution control factor in its determination of natural gas transmission and use cases, (b) enlistment of the manpower and other resources of the FPC in developing appropriate services and studies of the electric power generating industry and the natural gas production and distribution industries in order to gather information on control technology, clean fuels, and data on the cost thereof for the purpose of implementing the policies and procedures required by the Clean Air Act as amended and the Air Quality Act of 1967, (c) working with the Departments of

Housing and Urban Development (HUD) and Transportation (DOT) to utilize air pollution control knowledge and technology in the design and construction of Federal housing and urban renewal projects and the interstate highway and public roads systems, (d) involving DOT's Federal Aviation Administration (FAA) in NAPCA's study of the feasibility and practicability of controlling emissions from jet and piston aircraft engines and of establishing national emission standards for this purpose in order to report to the Congress as required by the Air Quality Act of 1967, and (e) consulting with the Department of the Interior pursuant to Presidential Proclamation 3794 of July 17, 1967, with regard to the issuance or modification of oil import regulations for the purpose of encouraging the availability of low sulfur residual fuel oil in areas requiring such fuels in order to meet State and local air pollution control emissions standards.

As a further means of communicating NAPCA's research and development activities, a summary of every project (including inhouse, grant, contract, and interagency work) related to air pollution is transmitted to the Science Information Exchange of the Smithsonian Institution. Through this system, up-to-date information on HEW's air pollution R&D activities is available to Federal agencies and non-Federal organizations.

Problems relating to air pollution research and control are among the concerns of the Environmental Quality Committee of the Federal Council on Science and Technology, Office of Science and Technology. Representatives of the Department of Health, Education,

and Welfare have participated in the work of various subcommittees, including those pertaining to research and development, environmental monitoring and surveillance, solid waste disposal, noise, standards, and information-education-manpower.

A. Control of Air Pollution from Federal Facilities

The program for abatement of air pollution from Federal facilities is governed by the Air Quality Act of 1967, Executive Order 11282, and Bureau of the Budget Circular A-78. Each Department and agency must comply with the regulations accompanying the Executive Order. The Federal Facilities Section of NAPCA provides technical assistance as required, to the agencies as well as an administrative and technical review of the five-year phased and orderly plan for the Bureau of the Budget.

On July 1, 1968, the first reports of progress under the plan were reviewed. A total of 387 installations reported 442 remedial actions located in 45 States, the District of Columbia, Puerto Rico, and Guam. For the most part these actions reflect conditions on April 1, 1968, as called for in the plan, and represent efforts of the agencies to abate air pollution by using their normal appropriations. The first year of planned funded activity will be FY 1969 because of the length of the Federal budget cycle and the fact that all reported activity occurred prior to that time. The actions represent relatively small expenditures for small projects. Generally, the projects included elimination of open burning, modification of incinerators or boilers, changes to lower sulfur fuel,

control of gasoline and solvent vapors, and engineering design work to complete similar and more difficult projects in future years. A summary of remedial actions is shown in Table 1.

Table 1. Summary of Remedial Actions by Federal Departments or Agencies--FY 1963

	Progress Reports No.	Remedial Actions No.	Stopped Open Burning or Poor Incineration	New or Upgraded Incinerators	New Heating Plants Constructed	Existing Heating Plants Improved	New or Improved Particulate Collectors	Smoke or Other Monitor Systems Installed	Using Lower Sulfur Content Coal or Fuel Oil	Converted Heating Plant to Burn Gas	Converted to Electricity	Reduced Chemical or Vapor Emissions	Other*
Grand Totals	387	442	126	9	14	7	8	16	103	37	1	31	90
DEFENSE ARMY	88	115	25	3	1	1	3	4	56	3		7	12
DEFENSE NAVY	67	94	7		2	1		8	22	3		15	36
DEFENSE AIR FORCE	39	43	13	2	1	3	2	1	5	2		6	8
DEFENSE SUPPLY AGENCY	1	1	1										
DEFENSE C. ENGINEERS	2	5				1			1				3
ATOMIC ENERGY COMMISSION	15	20	3	1		1	1	3	1			2	8
COMMERCE	3	4							2	1			1
GENERAL SERVICES	13	14							2	8			4
HEALTH, EDUCATION, WELFARE	11	11	1	2					7	1			1
INTERIOR	11	12	2						4	2			4
JUSTICE	20	2							1				1
NAT'L AERONAUTICS & SPACE	3	3											3
POST OFFICE	69	69	68							1			
SMITHSONIAN INSTITUTION	1	2	1										1
TENNESSEE VALLEY AUTHOR.	6	7					2				1	1	3
TRANSPORTATION	4	4	2						2				
VETERANS ADMINISTRATION	34	36	3	1	10					17			5

*"Other Actions" include Studies, Designs, Project Cost Estimates completed or underway. It also includes Contracts awarded or advertised for bid.

VII. AUTOMOTIVE AIR POLLUTION, EMISSION STANDARDS AND RELATED ACTIVITIES

A. Automotive Air Pollution Control

This section covers progress in three areas: the setting of national emission standards, the research and development of improved emission controls, and the assurance of compliance with Federal standards.

Automotive sources continue to emit more pollutants than all stationary sources combined. The automobile is responsible for over 90 percent of all carbon monoxide, 60 percent of the hydrocarbons, 50 percent of the oxides of nitrogen, and virtually all of the lead emitted into the Nation's air.

The Federal program has sought to cope with automotive air pollution by establishing nationwide standards that limit the emissions of carbon monoxide and hydrocarbons, based on the technical and economic feasibility of their control. It has sought to advance the state-of-the-art of automotive control technology through a research and development program aimed both at complementing and stimulating industry's efforts. Finally, it has initiated an active program to examine the effectiveness of emission control devices as the vehicles acquire mileage.

1. National Emission Standards. The Federal automotive emission standards, adopted in March 1966, apply to new gasoline-powered passenger cars and light trucks beginning with the 1968 model year. These standards were set on the basis of the maximum degree of control possible consistent with considerations of technological feasibility and economic costs, as well as on evaluation of the need for control from the standpoint of protection of public health and welfare.

Although the national emission standards for 1968 and 1969 model year vehicles were expressed in terms of concentrations, i.e., ppm of hydrocarbons and percent of carbon monoxide, an improved and more informative expression of the standard is in grams per vehicle mile. The 1968 and 1969 national standards are equivalent to 33 grams per vehicle mile of carbon monoxide and 3.2 grams of hydrocarbons for the average vehicle.

In June of 1968 the Secretary issued revised standards applicable to 1970 and 1971 model year vehicles. These standards represent the second step in the battle with the ubiquitous automobile for clean air. Although the 1968 and 1969 models are lower emitters, pollution is not expected to be reduced because the total vehicle population continues to grow.

The new standards are expressed in terms of grams per vehicle mile. Table 2 shows the effect of both standards on typical vehicles. It shows the reduction in allowable emissions permitted from new gasoline-powered motor vehicles. Not shown in the table, but also of significance, is that the 1970 regulations for the first time set performance standards for smoke emissions from diesel-powered trucks and buses.

The expected achievements of control measures now required can be seen in Table 3, also the estimated effectiveness of these standards on the total national pollution burden from motor vehicles. The estimated results of controls called for by both the initial and revised national emission standards are shown.

It should be noted that due to the increasing use of motor vehicles there is a time lag before any noticeable change occurs in total national

Table 2. PRESENT AND FUTURE AUTOMOTIVE POLLUTANT EMISSIONS

	Pre-1968 Uncontrolled Vehicles		1968 National Standards			1970 National Standards			1971 National Standards		
	Typical Emissions 1963 Car gms/veh.mile	Estimated Pollution lbs/car/yr	Typical Emissions 1968 Car gms/veh.mile	Estimated Pollution lbs/car/yr	Percent Reduction	Typical Emissions 1970 Car gms/veh.mile	Estimated Pollution lbs/car/yr	Percent Reduction	Typical Emissions 1971 Car gms/veh.mile	Estimated Pollution lbs/car/yr	Percent Reduction
Exhaust											
Hydrocarbons	9.7	215	3.2	70	67	2.2	50	78	2.2	50	78
Carbon Monoxide	71.0	1,575	33.0	725	53	23.0	500	68	23.0	500	68
Crankcase Blowby											
Hydrocarbons	4.8	105	0	None	100	0	None	100	0	None	100
Evaporation											
Hydrocarbons	3.9	85	3.9	85	0	3.9*	85*	0*	0.4	10	90
Totals											
Hydrocarbons	18.4	405	7.1	155	62	6.1	135	67	2.6	60	85
Carbon Monoxide	71.0	1,575	33.0	725	53	23.0	500	68	23.0	500	68

*Evaporation control is optional under Federal regulations in 1970 model year; but some manufacturers will provide evaporation control nationwide since it is required in California under HEW waiver of Section 208(b) of the Clean Air Act.

Table 3. National Control of Motor Vehicle Emissions

	1966	1967	1968	1969	1970	1971
Total emissions prevented by controls (millions of tons) (cumulative reductions)						
Hydrocarbons	1.3	1.8	2.8	3.9	5.2*	6.9*
Carbon monoxide	0.4	0.9	5.8	11.2	18.1	25.0
Total national auto emissions (millions of tons/year)						
Hydrocarbons	10.3	10.5	10.7	10.7	10.1*	9.6*
Carbon monoxide	61.9	65.3	66.5	67.2	66.4	58.8

*The effect of California's 1970 evaporative control standard is not included.

automotive emissions. Thus in Table 3, the 1968 and 1970 standards do not reduce total emissions from all motor vehicles to below 1966 levels until 1971.

In the years after 1971 the 1968 and 1970 standards will achieve a sharp downturn in national emissions. This downturn, however, will unfortunately be short lived. The increases in vehicle population and vehicle usage, will again begin a rise in pollution levels by the mid-seventies.

Consequently the current standards will only improve the situation in the short run. To solve the problem will require improved emission control systems and more restrictive standards. To this end, NAPCA is expanding its research and development efforts.

2. Automotive Emission Control--Research and Development. Although the primary responsibility for developing emission control systems lies with the vehicle manufacturers and fuel producers, the purpose of the Federal program is to stimulate, complement, and assist in furthering the development of improved control systems. NAPCA has undertaken a variety of research and development projects to carry out its responsibilities. Projects are conducted (1) within NAPCA laboratories, (2) in other government agencies at the Federal and State levels, (3) under contract with corporations and universities, and (4) by cooperative research jointly funded by the Federal government and private industry groups.

a. Conventional Engines. Plans have been set to organize a study on the control of particulate emissions from motor vehicle engines. This research and development will be directed towards gap areas in the

control technology for particulate emissions, with the goals of developing a simple, long-lived, exhaust system device for eliminating a substantial portion of the lead particulates which otherwise are emitted to the atmosphere. Consideration will also be given in this study to the control of diesel exhaust smoke.

The First National Symposium on Heterogeneous Catalysis for Control of Air Pollution, co-sponsored by NAPCA and the Franklin Institute, was held during the reporting period. A synopsis of the proceedings of this symposium will be published early in 1969. The symposium served to bring forth considerable information concerning research activities in this field with application to motor vehicle emissions control. This information will serve to guide NAPCA in planning research which will complement the efforts presently going on in industry and continue to stimulate such efforts.

In a continuing study on human responses to diesel exhaust odor, Southwest Research Institute is designing and constructing mobile odor presentation facilities suitable for use by selected human subjects, utilizing a high production diesel engine. A suitable questionnaire will be designed to elicit responses denoting the reactions, adverse or otherwise, of these subjects to odors. This information will assist in establishing a basis for Federal odor standards. Additional NAPCA sponsored research involving odor and other aspects of diesel emissions is in progress at the Bureau of Mines Petroleum Research Center, and Arthur D. Little Laboratories. The latter project is co-sponsored with private industry through the Coordinating Research Council. In addition,

increasing evidence of research by private industry on odorant identification has appeared through press releases and technical papers. Through all these means, it is believed that identification of certain classes of odorous materials in diesel exhaust will be made during the coming year. The information generated by these parallel studies should prove applicable to characterization of odors generated by turbine engines and other continuous flow combustion systems as well.

A project is now in progress with Battelle Memorial Institute to conduct analytical studies of fuel atomization, vaporization and mixing, and to evaluate the applicability of different fuel atomization methods to motor vehicle power plants. The results of this work will be applied to decisions concerning future research aimed at emissions reductions by means of fuel induction system changes.

Plans have also been formulated for initiation of research directed towards materials of construction having suitable high temperature properties for exhaust manifold reactors designed to thermally oxidize carbon monoxide and hydrocarbons. This work will be done through the National Aeronautics and Space Administration, Lewis Flight Propulsion Center.

As was noted in the first report the Automobile Manufacturers Association and the American Petroleum Institute are funding through the Coordinating Research Council a three-year research program to generate knowledge on factors influencing automotive air pollution. Many of these projects are co-sponsored by NAPCA. Some of these which relate to emissions control research are: (1) a study on the influence of gasoline

volatility on exhaust and evaporative emissions in which NAPCA is cooperating in funding the part which considers the influence of gasoline volatility on vehicle driveability; (2) a study on the relationship between sensory measurements of diesel exhaust odor and exhaust composition, referred to earlier; and (3) a study on the kinetics of oxidation and quenching of combustibles in gasoline engines, the objective of which is to improve knowledge of the burning processes which lead to pollutant origins and disappearance under conditions typical of gasoline engine combustion and exhaust systems.

b. Alternate Low-Emission Power Plants. A study by Arthur D. Little has been completed in which various types of electric propulsion systems were evaluated. It was determined that a propulsion system with sufficient power to weight ratio and energy storage capacity for family car use could be developed within ten years under a properly organized research program.

A project was completed under contract to gather information on emissions from aircraft. The work served as the basis for the report to Congress required by Section 211(b) of the Air Quality Act of 1967. The report is to be published in early 1969.

In addition, participation in aircraft industry committee groups sponsored both by the Society of Automotive Engineers and the Coordinating Research Council has produced the impression that intensive efforts are in progress to eliminate visible smoke emitted by all new power plants (and certain existing power plants as well) by combustor

design. Hydrocarbons and carbon monoxide emissions from aircraft gas turbines are a problem at idle and taxi power settings, which may constitute local problems in certain terminal areas. Control of these emissions by combustion system design is also believed feasible.

3. Certification. NAPCA maintains an emission compliance laboratory near Detroit, Michigan to certify new motor vehicles which meet the Federal emission standards. Here tests are conducted on prototype vehicles submitted by manufacturers prior to production. These tests which include exhaust gas sampling and analysis, are conducted in accordance with procedures established by NAPCA to determine compliance with the Federal emission standards.

The program for certification of 1968 and 1969 model passenger cars and light commercial vehicles required the review of applications from approximately fifty companies located in seven countries. The laboratory performed 730 and 1,083 emission tests for 1968 and 1969 vehicles respectively to establish eligibility for certification. Test scheduling was somewhat irregular to allow time for the vehicles to acquire mileage and to enable the manufacturers to conduct their own emission test programs. Scheduling was a particular problem during the spring and early summer of 1967, and again in 1968, when an extremely large number of prototype models were submitted by domestic manufacturers for certification. The certification of prototypes of foreign vehicles, on the other hand, was carried out at a relatively constant level. Some certification testing for 1969 sales was done as late as the summer of 1968. On the whole, the laboratory facilities proved generally adequate for [illegible] certification of 1969-model vehicles.

At present, certification activities are involved with changes in current models, the introduction of new mid-year models, and new applications from manufacturers. Test requirements are greater, however, for the certification of 1970 models that have different engines and control systems from those currently in use. Enlarged facilities will be necessary to carry out the more complicated tests required by the 1970 regulations.

4. Surveillance. NAPCA is attempting to determine the relationships between the test results of prototype vehicles and the emission characteristics of vehicles under normal use. Studies include testing of representative mass production vehicles. NAPCA is also studying the changes, with age and use, of emission characteristics of motor vehicles operated in actual service.

A national surveillance study has been initiated to determine whether vehicles actually comply with the Federal regulations. The study will provide statistically gathered information to evaluate the air pollution emission control performance of certified production model vehicles. Motor vehicle exhaust emissions may vary in different parts of the country due to such factors as climate, topography or urban development, so it is necessary to determine whether previously certified vehicles are conforming to the Federal standards in all areas of the country. The United States has been divided into eight atmospheric areas. Ultimately, it is desired to obtain motor vehicle emission exhaust data from each area. The purpose of the first phase of the national surveillance study is to obtain exhaust

emission data from that geographic region designated as "Great Plains Area." One-hundred and sixty statistically selected vehicles will be tested, three times each, for a total of 480 tests.

Surveillance studies are being conducted in the Los Angeles area by the West Coast laboratory, and in the Detroit area by the laboratory at Willow Run Airport. In each area, vehicles are procured through commercial rental agencies. Approximately 1900 vehicles from these sources are being tested. Tests are also being conducted on approximately 60 vehicles provided by car manufacturers for the Willow Run surveillance fleet.

5. Inspection Programs. One possible way to assure that vehicles in the hands of the public continue to effectively control emissions over the years is through periodic inspections. Under the Air Quality Act (Section 209), Federal grants may be made to appropriate State air pollution control agencies in an amount up to two-thirds of the cost of developing meaningful uniform inspection and testing programs for motor vehicle emissions and emission control devices. No such grants have been funded to date. NAPCA has underway several projects to aid in the development of inspection procedures and test instrumentation for State programs.

Thus far, two schemes have been proposed for periodic emission inspections to be undertaken at the State level. One of these, developed under a Federal grant to the State of New Jersey, involves the operation and testing of vehicles according to an abbreviated test cycle. The second, offered for consideration by an

industrial firm, comprise three different models capable of showing consistent results upon repetition. Within the limitations imposed by time, personnel and facilities, NAPCA is examining these two techniques with the use of prototype emission-controlled vehicles. The tests attempt to determine if the cycles accurately indicate control system malfunction and if they correlate with Federal test procedures. A number of experimental analytical instruments which have been submitted by private sources are also being evaluated. In addition, several systems studies are underway to analyze the cost-effectiveness of a variety of possible inspection and maintenance schemes.

At this early date, the evaluations being conducted by the NAPCA have not progressed far enough to recommend to the States the adoption of any one test instrument or inspection procedure.

b. Emission Control System Evaluation (Gasoline Engines)

a. Carbon Monoxide and Hydrocarbon Control. Efforts are continuing to achieve greater control of these two pollutants which are presently regulated to levels approximately one-third of the average of uncontrolled vehicles. Fuel injection and high efficiency carburetion systems show promise for improved distribution and cleaner air-fuel mixtures resulting in further emission reduction. Some improvements are also obtainable from modifications of engine design features such as combustion chamber geometry, piston ring configuration and valve timing. These emission control techniques are under study either in-house or by contract.

b. Nitrogen Oxide Control. Studies of various control techniques are in progress. A study by Esso Research and Engineering Corporation has progressed from an engine dynamometer optimization phase to fully automated vehicle installations of exhaust gas recirculation systems. These systems, achieving 80 percent reduction of oxides of nitrogen, are compatible with commercially available hydrocarbon and carbon monoxide control. A follow-up study is being negotiated to evaluate durability of the system.

A parallel evaluation of another oxides of nitrogen control system design is being supported in California by a NAPCA grant. In that too, emphasis is on durability and compatibility with hydrocarbon and carbon monoxide control systems.

7. Emission Test Procedures. To achieve an effective reduction in vehicle emissions, it is necessary to have accurate methods of measuring emissions under realistic operating conditions. Improved measurement systems are actively being sought.

Currently, there are five major areas in which engineering activities are concentrated: (1) development of simple dynamometer test cycles which better simulate urban driving conditions for light duty vehicles (less than 6000 lbs.) and three classes of heavy duty vehicles; (2) development of a simplified sampling system which gives an accurate measure of the total mass of pollutant emissions from the exhaust of all sizes and types of vehicles and engines; (3) development of a simplified fuel evaporative loss measuring system which measures all fuel losses from a non-operating vehicle including those due to

ambient temperature changes and those due to residual engine heat when turned off; (4) development of inexpensive but effective instrumentation and test cycles for State inspection stations; and (5) evaluation of measuring techniques for exhaust pollutants not currently regulated, such as oxides of nitrogen and hydrocarbon oxygenates.

The major accomplishments in the area to date by NAPCA personnel include: (1) development of a dynamometer cycle for light duty vehicles which simulate road conditions with respect to emissions; (2) development of a variable dilution proportional sampling system which measures the mass of emissions; (3) development of a simplified exhaust sampling collection method which allows for greatly reduced instrumentation requirements for multiple dynamometer test facilities; and (4) demonstration that complex dynamometer cycles may be used with the simplified sampling system without appreciable increases in test cost or manpower requirements.

In addition, accomplishments by others, either under contract or by encouragement, include development of: (1) non-dispersive infrared analyzers for the measurement of nitric oxide; (2) an ultraviolet instrument for the detection of nitrogen dioxide; (3) inexpensive instruments for the measurement of carbon monoxide and hydrocarbons; (4) inexpensive engine adjustment procedures; (5) a short dynamometer cycle for inspection procedures; (6) a key-mode dynamometer procedure which determines if the vehicle engine is operating as it was intended; and (7) dynamometer test cycles for heavy duty trucks.

8. California Emission Control Standards. The Clean Air Act as amended (Section 208), recognizes that "compelling and extraordinary conditions" might warrant State vehicular emission standards that are more stringent than the Federal standards. Therefore, the Act provides that Federal regulations will be waived in any State which had adopted vehicle emission standards (other than crankcase emission standards) prior to March 30, 1966, unless the Secretary finds that the State does not require stricter standards, or that the State standards and accompanying enforcement procedures are not consistent with the Act. California is the only State thus far that has applied for a waiver. On January 15-17, 1968, and on June 5, 1968, the Secretary held public hearings in California to provide an opportunity for all views to be expressed. Presentations were made by members of the State of California, the automotive industry, and other interested parties.

On July 16, 1968, the Secretary found that: (1) California had, prior to March 30, 1966, adopted standards (other than crankcase emission standards) for the control of emissions from new motor vehicles and new motor vehicle engines; (2) California requires standards more stringent than applicable Federal standards to meet compelling and extraordinary conditions; (3) California State standards and related enforcement procedures are more stringent than the applicable Federal standards, and are required to meet such compelling and extraordinary conditions; and (4) such State standards and procedures are consistent with Section 208(a) of the Clean Air Act, as amended.

Based on these findings the Secretary waived the application of Section 208(a) to the State of California with respect to the following identified State standards and test procedures: (1) California Exhaust Emission Standards and Test Procedures for 1969 Model Heavy Duty Vehicles; (2) California Exhaust Emission Standards and Test Procedures for 1969 Model Passenger Cars (Light Duty Vehicles); and (3) California Fuel Evaporative Emission Standards and Test Procedures for 1970 Model Light Duty Vehicles.

The waiver is applicable only with respect to the model years specified above.

On September 27, 1968, the Secretary received another request for a waiver from the State of California. This second request was prompted by the enactment of the California Legislature of the Pure Air Act of 1968. This Act establishes a number of increasingly stringent motor vehicle emission standards applicable to 1970, 1971, 1972, 1973, and 1974 model years vehicles as shown in Table 4.

Emission standards and test procedures to implement the law were adopted on November 20, 1968, by the California Air Resources Board. Public hearings will be scheduled promptly to provide the Secretary with information on which to base a decision on whether this waiver may be granted.

9. Uncontrolled Foreign Automobiles. NAPCA is increasingly concerned about the importation of foreign-built motor vehicles not equipped to control emissions in accordance with the national emission standards applicable to new vehicles sold in this Country. The entry of such vehicles is legal under the provisions of the Clean Air Act

Table 4. California Vehicle Emission Standards

I.	Gasoline-Powered Motor Vehicles Under 6001 Pounds Manufacturer's Maximum Gross Vehicle Weight Having an Engine Displacement of 50 Cubic Inches or Greater	
	A. Exhaust Emissions	
	1. 1970 Model Year	2.2 grams per mile hydrocarbons 23 grams per mile carbon monoxide
	2. 1971 Model Year	2.2 grams per mile hydrocarbons 23 grams per mile carbon monoxide 4.0 grams per mile oxides of nitrogen
	3. 1972 and 1973 Model Years	1.5 grams per mile hydrocarbon 23 grams per mile carbon monoxide 3.0 grams per mile oxides of nitrogen
	4. 1974 and Later Model Years	1.5 grams per mile hydrocarbons 23 grams per mile carbon monoxide 1.3 grams per mile oxides of nitrogen
	B. Evaporative Loss	
	1970 and Later Model Years	6 grams hydrocarbons per test
II.	Gasoline Powered Truck-Tractor or Bus Over 6001 Pounds, Manufacturer's Gross Vehicle Weight	
	A. Exhaust Emissions	
	1. 1970 and 1971 Model Years	275 ppm of hydrocarbons 1.5 percent carbon monoxide
	2. 1972 and Later Model Years	180 ppm of hydrocarbons 1.0 percent carbon monoxide

if the vehicles are not "new" as defined by the Act. Thus, slightly used, uncontrolled 1968 and 1969 model year foreign built vehicles may legally be imported for resale in large numbers. The extent of this activity is presently being investigated by NAPCA. No accurate figures have been obtained yet, but it is estimated that thousands of such vehicles are entering each year.

Furthermore, any individual who presently wishes to, may import an uncontrolled vehicle for his own personal use or in the words of the Act, for purposes other than sale or resale. No accurate figures are available on this type of importation either. It is believed, however, that thousands of uncontrolled vehicles are also entering each year under this provision of the Clean Air Act.

Although an individual vehicle may not create an air pollution problem, the combined emissions from large numbers of uncontrolled vehicles will add a significant burden to the air quality of major metropolitan areas.

10. Registration and Evaluation of Fuel Additives. Progress in fuel additives registration has taken place on two broad fronts: the gathering of information and the design of procedures. The two activities have usually been carried out simultaneously.

a. Information Gathering. Information on fuel additive usage has been accumulated from both public and private sources. A survey of fuel and fuel additive manufacturers has been completed by an outside contractor. The summary report for this survey provides the following listings: (1) all domestic fuel producers; (2) all domestic fuel additive producers; (3) all fuel or fuel additive

importers; (4) State by State fuel and fuel additive procedures; and (5) generic types of fuels and fuel additives being produced domestically, and the companies which produce each type.

NAPCA personnel gathered additional information in meetings with industrial representatives. The first meeting of the National Fuel Additives Advisory Committee was held in October. A large part of this meeting was devoted to a discussion of industry practices. In November administrative representatives attended a meeting of the American Petroleum Institute's Subcommittee on Environmental Standards. Fuel and additive company representatives at this meeting presented summary reports on each of the generic types of additives presently used in petroleum fuels. Both of these meetings provided NAPCA with a better understanding of the fuel additives problem.

b. Design of Registration Procedures. The design of registration procedures and regulations has proceeded well since the first report. Formal definitions have been drawn up for various terms used in the Act. Registration forms are being designed to handle the flow of information between NAPCA and the companies involved. A computerized system is being devised to handle the vast amount of information which will be gathered during the registration process.

Regulations describing the registration procedures are presently being drafted. The Notice of Proposed Rule-Making should be published early in 1969. The first fuel to be designated will be motor vehicle gasoline.

VIII. AIR POLLUTION MONITORING, DATA ACQUISITION, MEASURING INSTRUMENTATION, AND RELATED ACTIVITIES

An essential part of an environmental management program is the continuing appraisal of the quality of the environment. The quality of the Nation's air is being monitored by agencies at the Federal, State, and local level. At the Federal level NAPCA has as its primary objectives (1) providing an adequate nationwide baseline of air quality and source emission data, and (2) providing a continuing means for judging, on a nationwide scale, the effectiveness of air pollution control efforts.

There are three essential activities in an air pollution control agency that deal with air pollution monitoring and data acquisition:

(1) Continuous operation of a system for air monitoring adequate to measure the important pollutants in the ambient air, and sensitive enough to detect improvements resulting from control efforts.

(2) Continuous assessment of source emissions to define the reductions in quantities of discharged pollutants that will produce the desired air quality.

(3) Systematic storage and retrieval of the data on air quality and source emissions to facilitate the necessary analysis and evaluation. These activities are, in turn, essential to providing firm support to a sound abatement and enforcement policy.

A. Air Monitoring Systems

There are two basic types of air monitoring systems. The automatic, or continuous, sampler-analyzer systems produce numerical and/or graphical information directly. The non-automatic or intermittent systems employ

collection devices and separate laboratory facilities for subsequent analysis of the sample. The automatic system has the advantage of providing immediate information during air pollution episodes but usually does not retain the sample for future examination. The non-automatic system is necessarily slower in yielding information, but with the principal exception of bubblers for gas sampling, it usually produces a sample that can be stored for future verification and additional analyses.

NAPCA operates systems of both types. Approximate totals for the various major types of monitoring instruments operated by NAPCA are shown in Table 5.

By means of agency development and maintenance grants NAPCA is actively stimulating the assumption of air pollution control responsibility at the State and local level. Table 6 indicates the growth trends in these agencies as reflected in the number of various air monitoring instruments in use. The first column presents an inventory of instruments in use as of June 1967. The middle column shows instruments in use as of June 1968, and the third column shows rough estimates of the sampling activity anticipated by June 1969. The data for columns 2 and 3 are derived from a recent Federal survey questionnaire which was sent to 293 State and local agencies involved in air pollution control. Replies were received from 221 State and local agencies in time for inclusion in this summary. Some agencies were not in a position to estimate their level of activity for the next fiscal year; therefore, the 1969 projections are approximate only.

Table 5. NAPCA Air Monitoring Equipment

Device	Pollutant	1967	1968 (June)	Estimated June 1969
Non-Automatic				
Dustfall Jar	Settleable Particles	281	434	575
Lead Peroxide "Candle"	Oxidizable Sulfur Compounds	373	593	601
Hi-Vol	Suspended Particles	259	383	539
Tape Sampler (all)	Suspended Particles, H_2S	13	24	45
Bubbler	Gases	56	104	190
Sequential Bubbler	Gases	6	12	20
Automatic				
Sampler-Analyzer	Carbon Monoxide	7	16	22
"	Hydrocarbons	7	15	22
"	Nitric Oxide	10	17	22
"	Nitrogen Dioxide	10	17	22
"	Oxidants	7	18	24
"	Sulfur Dioxide	19	30	36

Table 6. State and Local Air Monitoring Equipment

Device	Pollutant	1967*	1968 (June)	Estimated June 1969
Non-Automatic				
Dustfall Jar	Settleable Particles	1651	2548	3131
Lead Peroxide "Candle"	Oxidizable Sulfur Compounds	1100	1764	2469
Hi-Vol	Suspended Particles	975	1459	1997
Tape Sampler (all)	Suspended Particles, H_2S	297	585	841
Bubbler	Gases	226	393	646
Sequential Bubbler	Gases	33	74	141
Automatic				
Sampler-Analyzer	Carbon Monoxide	59	93	186
"	Hydrocarbons	36	63	110
"	Nitric Oxide	41	45	91
"	Nitrogen Dioxide	43	48	101
"	Oxidants	80	83	137
"	Sulfur Dioxide	85	435	511

*based on a mid-year telephone inquiry

Figure 1 shows the geographic distribution of State and local automatic monitoring instruments. The number of automatic instruments in use by State and local agencies has risen from approximately 400 in 1967 to 624 in 1968 (based on 75 percent response to the questionnaire). In 1967 there were 23 States with agencies operating automatic instruments; in 1968 there were 34.

B. Inventories of Pollutant Emissions

An inventory of emission sources is essential to executing an effective air pollution control effort. On the balance sheet of an urban area's intake of goods, raw materials, and foodstuffs, as against its output of products and waste material, most of the quantities are well known, even to the solid wastes and sewage because they are collected and dealt with. One important term in the equation of mass flow through an urban area's economy, the quantity of waste substances discarded into the atmosphere, has until recently been largely ignored or estimated indirectly. In the last four to five years more detailed inventories have been initiated by Federal, State, and local agencies, so that by June 1968 some kinds of data on quantities of emissions had been collected for 75 of the 231 Standard Metropolitan Statistical Areas (SMSA)* in the United States. The emphasis is being placed on obtaining this information is evidenced in the fact that six months later, by the end of December 1968, the number had grown to 91. Most of the larger cities have been inventoried, as the following Table 7 shows:

*The Standard Metropolitan Statistical Areas are defined by the Bureau of the Budget as a county or group of counties that contain at least one central city of 50,000 inhabitants, or twin cities with a combined population of at least 50,000. It also includes any contiguous counties of metropolitan nature that are socially economically integrated with the center city.

Figure 1. State and Local Automatic Instruments

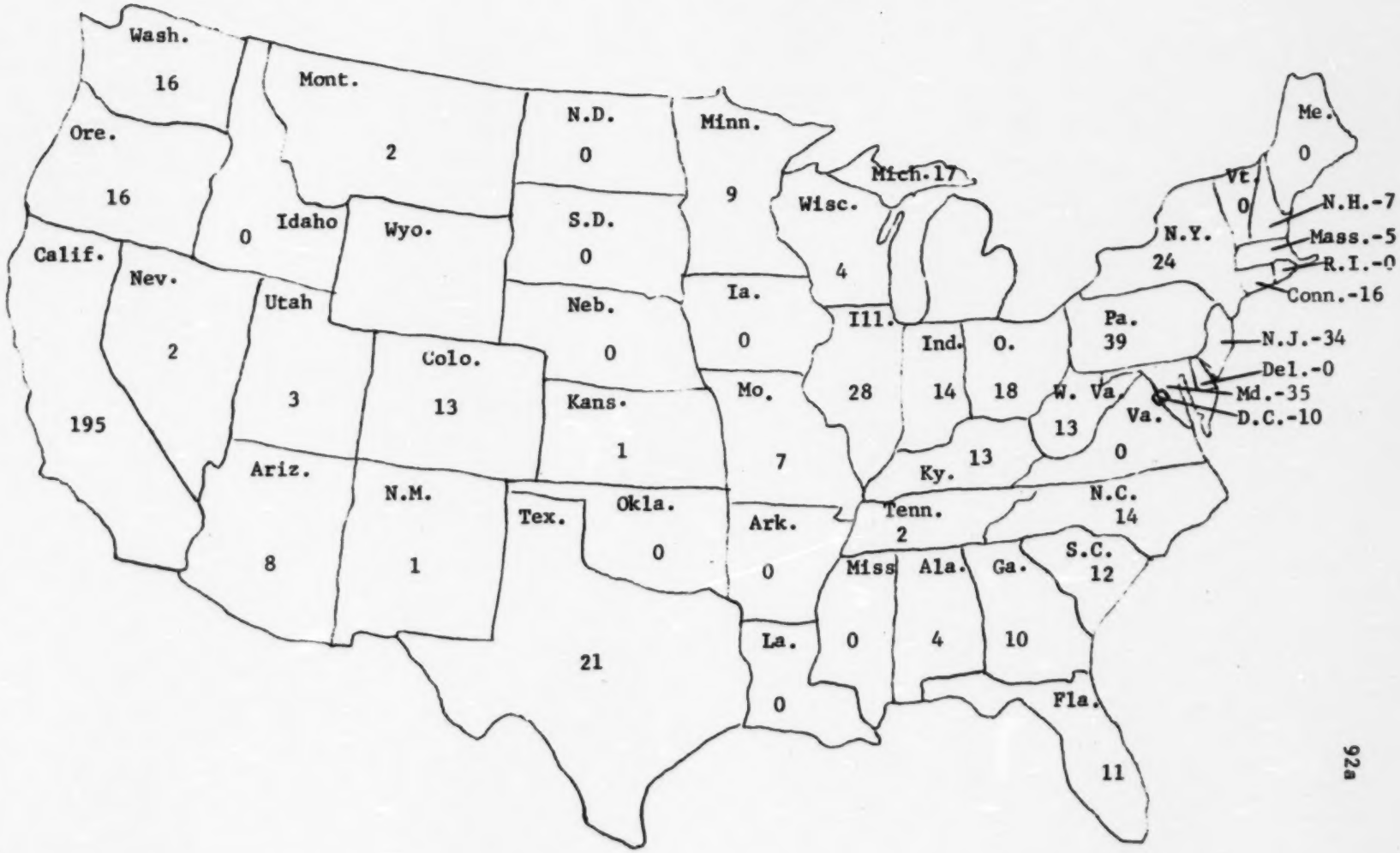

Table 7
COMPLETED INVENTORIES BY POPULATION CLASS, December 1968

SMSA Population	No. of SMSA's	No. Inventoried
1 million or more	24	23
500,000 to 1 million	33	20
100,000 to 500,000	142	45
Less than 100,000	32	3
	231	91

Elements of NAPCA have conducted or participated in 42 of these inventories, with the State or local personnel often providing a majority of the effort. Of the other 49, about half were conducted by State agencies; the remaining half by city, county, or regional control districts.

A major project of current urgency, the definition of air quality control regions, requires a comprehensive inventory of emissions in each area. Much of the data collected in the inventories conducted by State or local agencies is a valuable addition to the accumulating information. On the other hand, some early inventories are not being kept current, and 23 of the State or locally conducted inventories concentrate on the center city or areas that do not include the entire SMSA. This is understandable since locally conducted inventories are usually directed to immediate tasks such as identification of specific sources in problem neighborhoods, documenting the need for control and enforcement statutes, and allocating money and manpower to the control efforts that will yield the greatest benefit to air quality.

Inventories conducted by the Federal agencies cover an entire Standard Metropolitan Statistical Area, at least, and are designed to be kept current. The principal emphasis in these inventories is to assemble an area-wide picture of how types of emission sources are distributed and data on total quantities of emitted substances. In addition to providing one facet of the information needed to define the air quality control regions, the data are also to be used in long-term research on such problems as source-receptor relationships, testing of meteorological models, and in zoning and transportation planning.

The principal pollutants covered in an inventory are suspended particulate matter, carbon monoxide, oxides of nitrogen, oxides of sulfur, and hydrocarbons.

C. National Data Bank

The "Storage and Retrieval of Air Data" (SAROAD) System, which functions as a national air quality data bank, received contributions of data from approximately 250 State and local air monitoring stations in 1967; in 1968 the figure rose to 310.

Including Federal, State, and local monitoring stations, the data bank presently contains air quality information from 761 stations, representing approximately 410 urban and 55 nonurban areas, and 60 sites in fringe areas. It is anticipated that by 1971 data will be acquired from over 1,000 stations representing over 600 urban, 100 nonurban and 100 fringe areas; and by 1972, data from all existing air monitoring systems will be stored in a bank.

It is estimated that the cost of maintaining such a centralized data bank will be on the order of 3 percent of the total nationwide expenditures (Federal, State, and local) for the acquisition of the data, and an expenditure of an additional 5 percent would cover interpretive analysis and publication of the data.

D. Measuring Instrumentation

Excellent progress has been made since the first report in both intramural and contract work on development of instruments, particularly for stack measurements and air quality.

1. Instrumentation for Vehicular Emissions. The most efficient control of air pollution resulting from vehicular hydrocarbon emissions requires the ability to remove those hydrocarbons which are effective in causing eye irritation, visibility, plant damage, and health effects. Schemes for such an "atmospheric reactivity" assessment have been proposed by several investigators including those at NAPCA.[5]

Scales for such reactive hydrocarbons have been compared and found to produce similar results for current control systems. Since the results of simple scales may well provide adequate assessment for hydrocarbon control, NAPCA has developed and published instrumental techniques for reactive hydrocarbons.[6] These techniques allow reactive hydrocarbons to be measured with a minimum of expense and time. Such techniques also provide the opportunity to compare the performance of vehicle fleets on a more descriptive basis than by the previous research techniques.

A demonstration grant to the State of New Jersey, managed by Scott Laboratories, provided information about the degree of instrumentation needed and available to conduct individual car inspection. This program has provided considerable impetus to research on simplified instrumentation by the private sector and is expected to provide more in the immediate future.

2. Instrumentation for Stationary Sources. More rapid progress has been made in preliminary work on development of remote stack monitoring equipment than was anticipated in the first report.

a. Remote Stack Monitoring. Contractual work has been initiated to evaluate the performance of a continuous monitor that is commercially available and that has been developed to remotely monitor SO_2 and NO_2 in plumes from stack sources using correlation masking spectroscopy.

A prototype monitor has been developed on contract to continuously measure SO_2 remotely by emission spectroscopy. Performance evaluation in field operation is underway and preliminary results indicate that aerosols can be a significant interference.

A feasibility study will be undertaken by contract to investigate the application of Raman spectroscopy for remote monitoring of NO in plume emissions. A prototype lidar instrument will be developed for remote monitoring of particulate emissions from stack sources by measurement of optical transmittance.

b. In-Stack Monitoring. A fly ash prototype monitor for incinerator emissions has been developed by contract and evaluated in

the field. Results of tests done with automatic isokinetic sampling versus fixed flow sampling indicated that a relatively simple device without automatic isokinetic sampling can be used to adequately monitor particulate loading in the stack for air pollution control. The method is based on a beta-gauge technique applied to particulates collected on paper tape and is applicable to particulates emitted by various sources. A commercial instrument is presently available for iron oxide emissions from steel mills.

A contract for a field study has been initiated to evaluate the performance of a continuous monitor developed to measure SO_2 concentrations in a stack by an optical technique using correlation masking spectroscopy.

3. Instrumentation for Air Quality. Major progress has been made toward providing monitoring instruments for several of the most important pollutants.

a. Single-Point Sampling. A new commercially available detector for SO_2 has been evaluated in the laboratory, and shown to have the desired sensitivity and ability to operate in unattended stations. Techniques are available for increasing specificity of this instrument for SO_2, and will be applied should field studies show a need for them. An added benefit of these techniques is that they can be applied to the separation, characterization and quantitation of sulfurous compounds contributing to kraft mill odor problems.

A prototype semi-continuous gas chromatographic instrument has been assembled, having the capability for determining carbon monoxide and methane in air with a sensitivity far exceeding that of earlier devices. This device is presently being used in the

laboratory for the analysis of air samples collected in the field. Its further evolution, either as a field instrument or as a central laboratory device, will be determined in the light of the present study.

An earlier ozone-sonde device has been modified to permit the continuous, sensitive, real-time determination of ozone in air. Discrepancies between results obtained with this device and those from existing "oxidant" instrumentation are believed to be traceable to serious gaps in our knowledge of the chemistry of the ozone-"oxidant" family of pollutants. Studies now underway are expected to resolve the differences.

A laboratory method has been developed representing great improvement over previous techniques in both the sensitivity and specificity with which it can measure sulfuric acid mist. Invaluable data regarding the occurrence of this noxious aerosol should result from this development.

Research and development contracts have been let for feasibility studies of proposed instrumentation that holds great promise of being able to perform field monitoring of two or more pollutants simultaneously. The advantages of such a device are self-evident.

Nephelometers have been developed and are now commercially available to measure optical lightscatter by suspended particulates and research is currently underway to relate these measurements to mass loading and to visibility in the atmosphere. Preliminary results indicate that such lightscatter measurements can be a good

indirect method of continuous monitoring of mass concentration of suspended atmospheric aerosols without the need of sample collection and weighing.

The correlation masking spectroscopy technique has been adapted to point-sampling instrumentation in a prototype development for concentration measurements of SO_2 and NO_2 in ambient air. A field study has been initiated by contract to evaluate its performance in an urban atmosphere and to compare its measurements to those of another prototype development using the same analytical technique applied to long-path sampling.

b. Long-Path Sampling. A prototype instrument will be developed to measure ozone concentration over a long-path in urban atmospheres using an IR absorption spectroscopy technique. The method will have the potential to be adapted to the measurement of several other pollutant gases having IR absorption bands in the adjacent spectral regions.

A long-path IR absorption spectrophotometer will be developed to provide data on the effect of pollutant gases on the spectral transmission properties of the urban atmosphere and relate this information to the design, calibration, and performance evaluation of optical type instrument developments.

IX. ADVISORY GROUPS

A. President's Air Quality Advisory Board

The role of the President's Air Quality Advisory Board is to advise and consult with the Secretary on matters of policy relating to the activities and functions authorized under the Air Quality Act of 1967 and to make such recommendations as are deemed necessary to the President. The Board is composed of the Secretary or his designee as Chairman and 15 members appointed by the President, none of whom are permitted to be Federal officers or employees. The members represent various State, inter-state and local Governmental agencies, public or private interests contributing to, affected by or concerned with air pollution, and other public and private agencies, organizations and groups interested in the field of air pollution prevention and control, as well as other individuals expert in the field.

The 15 members of the Board were appointed by the President on July 25, 1968, with one-third of these members appointed to serve, respectively, terms of one, two, and three years. The first meeting of the Board on September 16, 1968, was devoted to the discussion of progress made in implementing the provisions of the Air Quality Act and to the exploration of ways in which the Board could assist the Department in achieving the goals of the Act. The second meeting of the Board will be at a date set by the Chairman early in 1969.

B. Advisory Committees

During the reporting period each of the following Advisory Committees has been extensively involved in activities peculiar to

that Committee: Research and Development, Fuel Additives, Air Quality Criteria, Control Techniques, Control Agency Development, and Research Grants.

Two new Advisory Committees were established and staffed during the reporting period. These were the Iron and Steel Industry Liaison Committee and the Primary Smelter Industry Liaison Committee. The purpose for their establishment is as follows:

The Iron and Steel Industry Liaison Committee is established to (a) review the scope of the systems engineering study of the air pollution problems relating to the industry, (b) provide pertinent data inputs from industrial sources as applicable, (c) participate in periodic contract progress reviews, and (d) evaluate the final study report. Recommendations regarding these phases of committee responsibility will be directed to the project officer for the study.

The Primary Smelter Industry Liaison Committee is established to (a) review the scope of the systems engineering study of the air pollution problems relating to the industry, (b) provide pertinent data inputs from industrial sources as applicable, (c) participate in periodic contract progress reviews, and (d) evaluate the final study report. Recommendations regarding these phases of committee responsibility will be directed to the project officer for the study.

Several other Committees have been established but not staffed. These Committees and their purposes are:

Air Pollution Economics Advisory Committee. The Committee is to assist in the development and implementation of the purposes of the Air Quality Act including the development of economic models for the study of the impact of alternate air pollution control methods both technical and social.

Air Pollution Chemistry and Physics Advisory Committee. This Committee is responsible for consultation regarding chemical, physical, and instrumental research and development activities directed towards improvement of air quality.

Air Pollution Process Control Engineering Advisory Committee. This Committee is responsible for consultation regarding engineering research and development activities directed toward the control of air pollutants from stationary sources (i.e., industrial, commercial, and domestic processes).

Meteorology Advisory Committee. The Committee is responsible for consultation and advice regarding all research and development activities in the field of air pollution meteorology undertaken by the Meteorology program of the National Air Pollution Control Administration.

Motor Vehicle Research and Development Advisory Committee. This Committee is responsible for consultation regarding the national research and development activities of the National Air Pollution Control Administration directed toward the control of air pollutants from all vehicular sources, i.e., on-road vehicles, off-road vehicles, aircraft, railroad, and ship.

Organic Solvents Advisory Committee. The Committee is responsible for consultation and advice regarding: amounts and types of solvents used nationally and regionally; general techniques for assessing organic solvent contributions to air pollution in an area; research currently underway and additional studies needed to determine the

relative importance of various solvents and mixtures of solvents; methods of classifying solvents as air pollutants; methods of evaluating effects and smog-forming tendencies, and the role of sunlight and meteorology; and the advisability and feasibility of national criteria for solvent use and regulation, as a guide to control agencies and industry.

Pulp Industry Liaison Committee. The Committee is established to (a) review the scope of the systems engineering study of the air pollution problems relating to the industry, (b) provide pertinent data inputs from industrial sources, as applicable, (c) participate in periodic contract progress reviews, and (d) evaluate the final study report.

X. MISCELLANEOUS ACTIVITIES

A. Government-Industry Meetings

NAPCA has long recognized the important role that industry has to play in the prevention and control of air pollution. Since its inception in 1955, the Federal air pollution program has worked to involve industry in air pollution control, and one of the ways it has done this is through a variety of joint industry-Government meetings.

During 1967 and 1968 a number of meetings were held bringing together representatives of industries with pollution problems and responsible staff of HEW/NAPCA and other concerned Federal departments and agencies. In accordance with the authority and mandate of the Air Quality Act of 1967 and the new Departmental organizational structure, there is under development a variety of meetings, seminars, and symposia for the exchange of information and ideas by experts and managers from industry and government.

B. International Affairs

An International Affairs program has been established with the objective of promotion and coordination of international programs within NAPCA. NAPCA engages in various international activities with the World Health Organization (WHO), the World Meteorological Organization (WMO), the Organization for Economic Cooperation and Development (OECD), the Economic Commission of Europe (ECE), the Council of Europe (COE), and the International Joint Commission (IJC); sponsors translation and research projects in Israel, Poland, and Yugoslavia under P.L. 480; represents the Department of Health,

Education, and Welfare (DHEW) in cooperative programs concerning air pollution control with Germany and Japan; and maintains liaison with the Office of International Health (OIH), Public Health Service (PHS), DHEW, and with Scientific Attaches of foreign Embassies. NAPCA awards research grants to foreign recipients. At the present time grants have been awarded to scientists in Austria, Canada, England, and Sweden.

An agreement between the United States and the Union of Soviet Socialist Republics on Exchanges in the Scientific, Technical, Education, Cultural, and other fields in 1968-1969, which contains for the first time air pollution, was signed in Moscow, July 15, 1968, by the United States Ambassador and the Director, Cultural Relations Department, Ministry of Foreign Affairs, U.S.S.R. This agreement is valid until the end of December 1969.

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